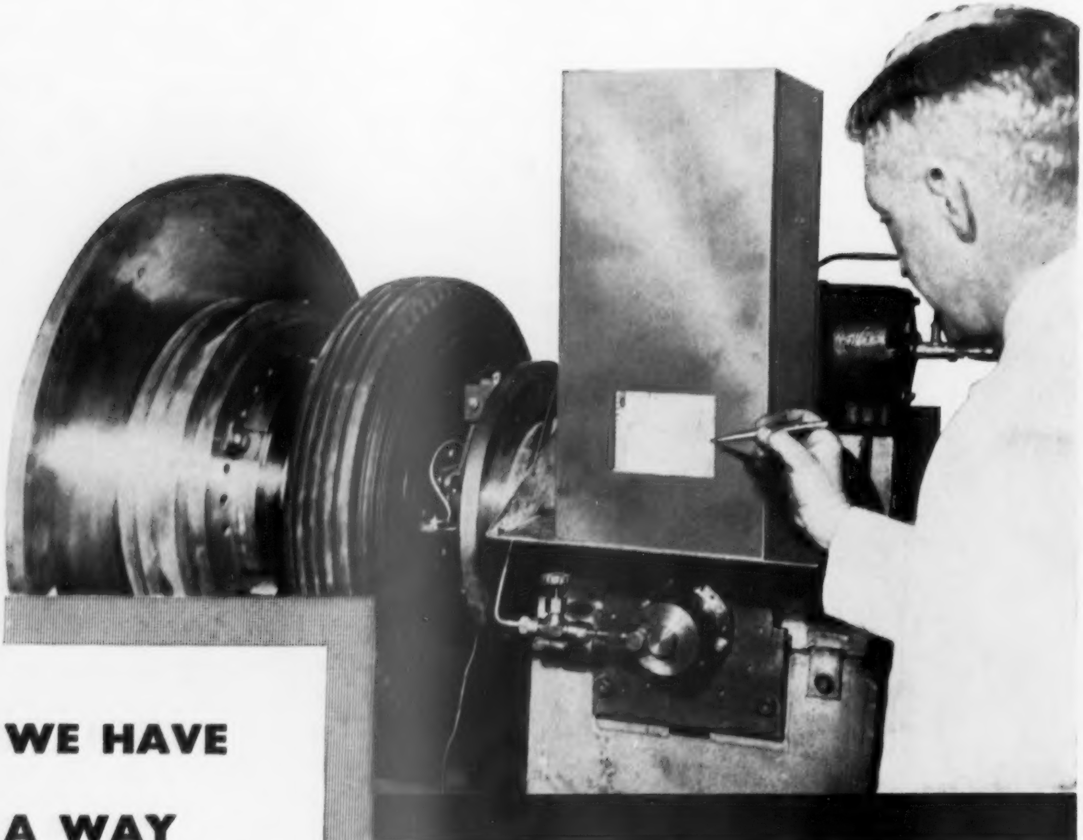
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 46 No. 5 MAY 1956 PRICE: 3s. 6d.



WE HAVE A WAY WITH BRAKES

Into our Research Department at Cleckheaton come all manner of problems to do with brakes. Here we can reproduce the actual service conditions under which brakes operate and check performance on machines and delicate instruments which leave no room for guesswork.

The work goes on unceasingly . . . much of it devoted to anticipating the problems of the future. Mintex leadership is based securely on the work done in our laboratories and research departments.

When high performance counts

you can rely on MINTEX

MINTEX BRAKE AND CLUTCH LINERS ARE MANUFACTURED BY BRITISH BELTING & ASBESTOS LIMITED, CLECKHEATON, YORKSHIRE

MAXIMATICS help speed Automobile output!

Our photograph shows part of a battery of MAXIMATIC Automatic Lathes installed in a well-known motor works for turning the ends of rear axle cases. The machines are fitted with central driving heads and have been responsible for a substantial increase in the output of turned axle cases.

Maximatics are available with maximum swing 18" or 22" and distance between centres 18", 30", 42" or 78".

MAXIMATIC

AUTOMATIC MULTI-TOOL LATHES

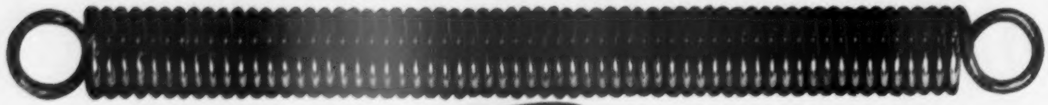
NATIONAL HALL, STAND No. 112.

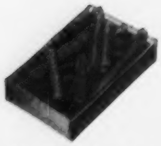
INTERNATIONAL MACHINE TOOL EXHIBITION 1956
June 22-July 6
Olympia · London

DRUMMOND BROS. LTD., GUILDFORD, ENGLAND

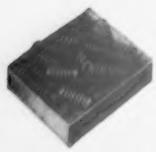
Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM
'Phone: Midland 3431 (7 lines) *Also at LONDON: 'Phone Trafalgar 7224 (3 lines) and GLASGOW: 'Phone Central 3411*
D 133

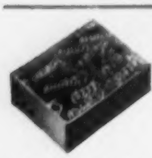




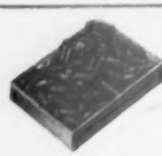
No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ⅛" to ½" diam. 6/6 each.



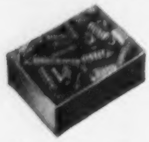
No. 98A. 3 doz. Assorted 1" to 4" long, ⅛" to ⅝" diam., 19G to 15G. 5/6 each.



No. 757. Extra Light Compression, 1 gross assorted, ⅛" to ⅜", ⅛" to 2" long, 27 to 20 S.W.G. 15/- each.

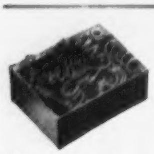


No. 388. ½ gross Assorted Small Expansion Springs. ⅜" to 1½", 18G to 21G. 9/6 each.

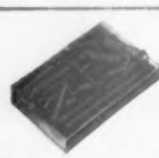


No. 758. Fine Expansion Springs. 1 gross Assorted ⅛" to ⅜", ⅛" to 2" long, 27 to 20 S.W.G. 15/- each.

No. 466. ½ gross Assorted Small Expansion Springs ⅜" to 1½" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.



No. 1013. 1 gross Small Coil Compression Springs, ⅜" to 1½" long, 3/32" to 7/16" diam., 24G to 19G. 6/- each.



No. 753. 3 doz. Assorted Light Expansion ⅛" to ½" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.

No. 1024. 20 Compression Springs 12" long. ⅛" to ½" diam. 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansions 1½" to 12" long, 5/32" to ⅜" diam., 22G to 16G. 24/- each.

How are you off for Springs?

TERRY'S BOXES OF ASSORTED SPRINGS are just the job for your experimental department — a wonderful assortment of Compression and Expansion Springs . . . all sorts of lengths, gauges, diameters. The nine boxes we show are just a few from our range. Why not let us send you a full list—free?

TERRY'S

ASSORTED SPRINGS

These Boxes of Springs can also be obtained at:

LONDON 27 Holborn Viaduct
MANCHESTER 279 Deansgate
BIRMINGHAM 210 Corporation Street

The prices quoted are subject to the usual trade discount.

HERBERT TERRY & SONS LTD. REDDITCH, WORCS · SPRING MAKERS FOR 100 YEARS

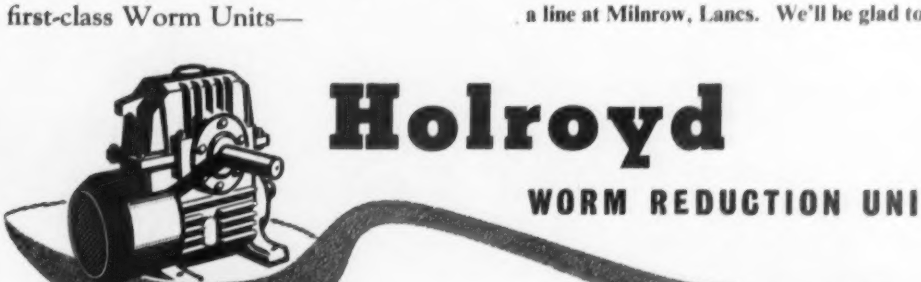
HT17(B)

Taking our own medicine

We're as pleased as a Manchester man at a Test Match that *hasn't* been rained off. We're taking our own medicine—using our own Worm Units all over our own works. And we're liking it, because these units are doing their various jobs so very well. Which is what you'd expect from the way we make them—on special machines and from special metals, both developed by us during 50 years of Worm Gear manufacture. That's the Holroyd prescription for first-class Worm Units—

MADE UP FOR YOU QUICKLY

A Standard Type Holroyd Worm Reduction Unit with a stock ratio can be made up, packed and despatched to you fairly quickly. Special units or worms and wheels made to order take somewhat longer. For information on our Worm Units, and on new applications for them (like the machine in the illustration) drop us a line at Milnrow, Lancs. We'll be glad to help you all we can.



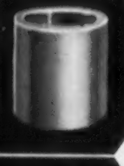
Holroyd

WORM REDUCTION UNITS

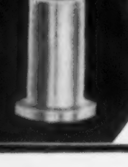
JOHN HOLROYD & COMPANY LIMITED · MILNROW · LANCS · TELEPHONE: MILNROW [illegible]

CRC 169

Increase output by simplifying your own machining programmes. For instance, use Compo and Powdiron Bearings, which are made by the powder metallurgy process to such close tolerances that they are ready for immediate installation. A simple press fit is obtained without reaming or machining, and their self-lubricating properties eliminate the need for oil holes — another saving in drilling time. Specify Compo and Powdiron and have bearings ready to fit accurately, simply and economically. Standard cylindrical bushes are available from stock in a wide range of sizes.



COMPO
POROUS BRONZE
BEARINGS



Powdiron
SINTERED IRON BEARINGS

BOUND BROOK BEARINGS LIMITED
TRENT VALLEY TRADING ESTATE · LICHFIELD · STAFFS
(A Birfield Company) Telephone: Lichfield 2027-2028

Like an iceberg

The stuff that does the damage is out of sight.

Directly it is put in, the clean Purolator 'Micronic' oil filter immediately begins to arrest those dangerous abrasives which, if left in free circulation in the oil, would wear away the important bearing surfaces. Even though the Purolator has a wonderfully efficient filter element with an exceptionally large area, nevertheless by its very efficiency it collects impurities which ultimately clog it. In order to safeguard the engine, we constantly advertise to car owners to fit a new element whenever they change the oil.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

PUROLATOR

Micronic OIL & FUEL FILTERS

Registered trade marks: Purolator, 'Micronic.'

The right kind of assistance

The two-leading shoe design has served the industry well but after a long range of experiment and research we have found that when compared with two shoes, each self-energising to some extent, the new Lockheed development of the leading and trailing shoe brake has several advantages. These are made possible by the use of differential area wheel cylinders to operate the shoes. The force applied to the trailing shoe is thus proportionately greater than that to the leading shoe; as a result, the shoes contribute equal braking effort and the linings wear equally.

Any frictional changes in the brake linings tend to cancel one another and in practice the brake is extremely stable under all operating conditions; has very good anti-fade properties and provides excellent retardation from all speeds at light pedal efforts.

In order to obtain the maximum efficiency from the brake and to eliminate unnecessary lost travel, all brakes have fully automatic adjusters, with positive ratchets supplementing the friction devices.

BRAKEMASTER TRADE MAR

The vacuum-operated servo-unit, having a vacuum valve hydraulically operated directly the brake pedal is pressed, causes the servo to boost the pressure to the wheel cylinders, but always proportionately to the pedal effort.

Should the engine stall or the vacuum fail, the pedal-operated normal hydraulic system remains operative.

Fully patented

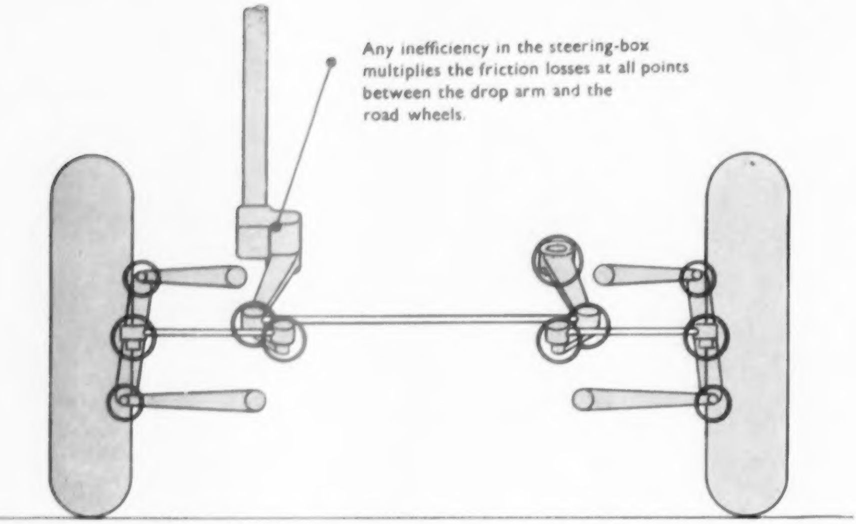
by Lockheed

REGD. TRADE MARK: LOCKHEED

AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

MAKING STEERING LIGHTER

Steering-Box Efficiency



The fact that the steering-box is the last link at the driver's end of the chain means that it exercises its inefficiency on all the other losses as well. This makes its efficiency very important.

A theory which has been put forward frequently and is probably still widely held is that if a steering-box is too efficient then joggle of the steering wheel due to road fight will be too pronounced. This probably dates from the days of front axles, when there was little that could be done about the gyroscopic torques that produce joggle (which were accentuated by progressive increases in rotating inertia, as bigger and better balloon tyres became popular) and the only hope of preventing the driver feeling the joggle was to bottle it up. Today this position no longer exists; a large majority of cars are fitted with the double wishbone independent front suspension which allows the amount of gyroscopic torque to be controlled by the layout. Joggle can therefore be reduced at its source and that excuse for an inefficient steering-box can no longer be given.

We may in passing mention that the process of bottling up had two parts; the provision of flexibility in the steering linkage, which reduced the transmission of joggle to the steering-box, and the provision of means to reduce as far as possible the reverse efficiency of the box. The first, the provision of steering linkage flexibility, merits fuller consideration elsewhere; the second has been a dream of many people, including the great Dr. F. W. Lanchester. As we have said, it is today no longer necessary, and this fact is one of many which allow better steering to be offered today than before.

To substantiate this statement we must first agree what constitutes good steering. This can be logically defined as that which causes the driver as little fatigue as possible. In this connection the reduction of physical fatigue by reducing effort is an obvious improvement. It is at least equally important, however, to help the car to steer itself; complete irreversibility of a steering would mean the complete absence of road feel, and the complete absence also of self-centring or straightening out after a corner. This is tiring both mentally, because of the incessant vigilance demanded of the driver, and physically because of the continued efforts demanded to put into effect the corrections shown to be necessary by that vigilance. Friction in the steering column is one way of reducing the reverse efficiency of a steering-box and it does, by observation, tend to produce the effects described above.

There has been a fairly general realization, with the passage of time, that rolling action rather than rubbing will give higher mechanical efficiencies in steering-boxes and if we look at the types of box used today we shall be able to observe the results of that realization. Let us hope that even higher efficiencies, and still better steering will appear and continue to be with us.

Thompson

Self-adjusting

STEERING AND SUSPENSION JOINTS

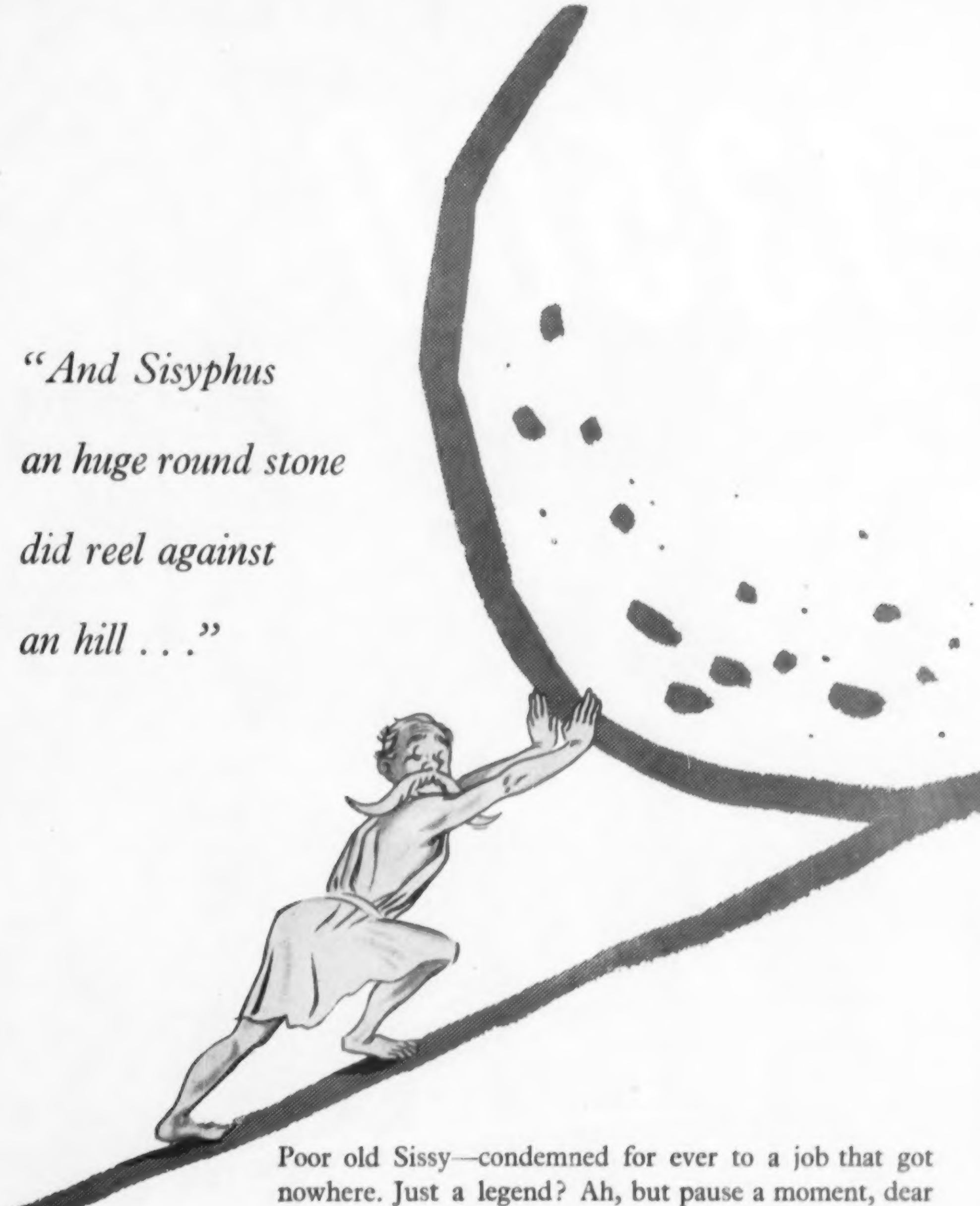
AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

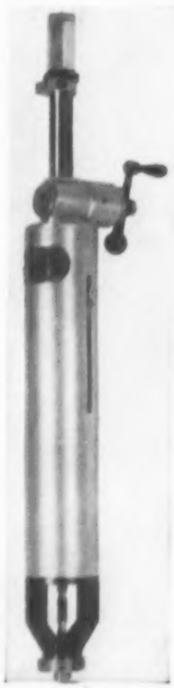
"And Sisyphus

an huge round stone

did reel against

an hill . . ."





Poor old Sissy—condemned for ever to a job that got nowhere. Just a legend? Ah, but pause a moment, dear friends. Are there not Sissies in many a works trying this very day to bore half-inch holes through tough metal with the wrong tool?

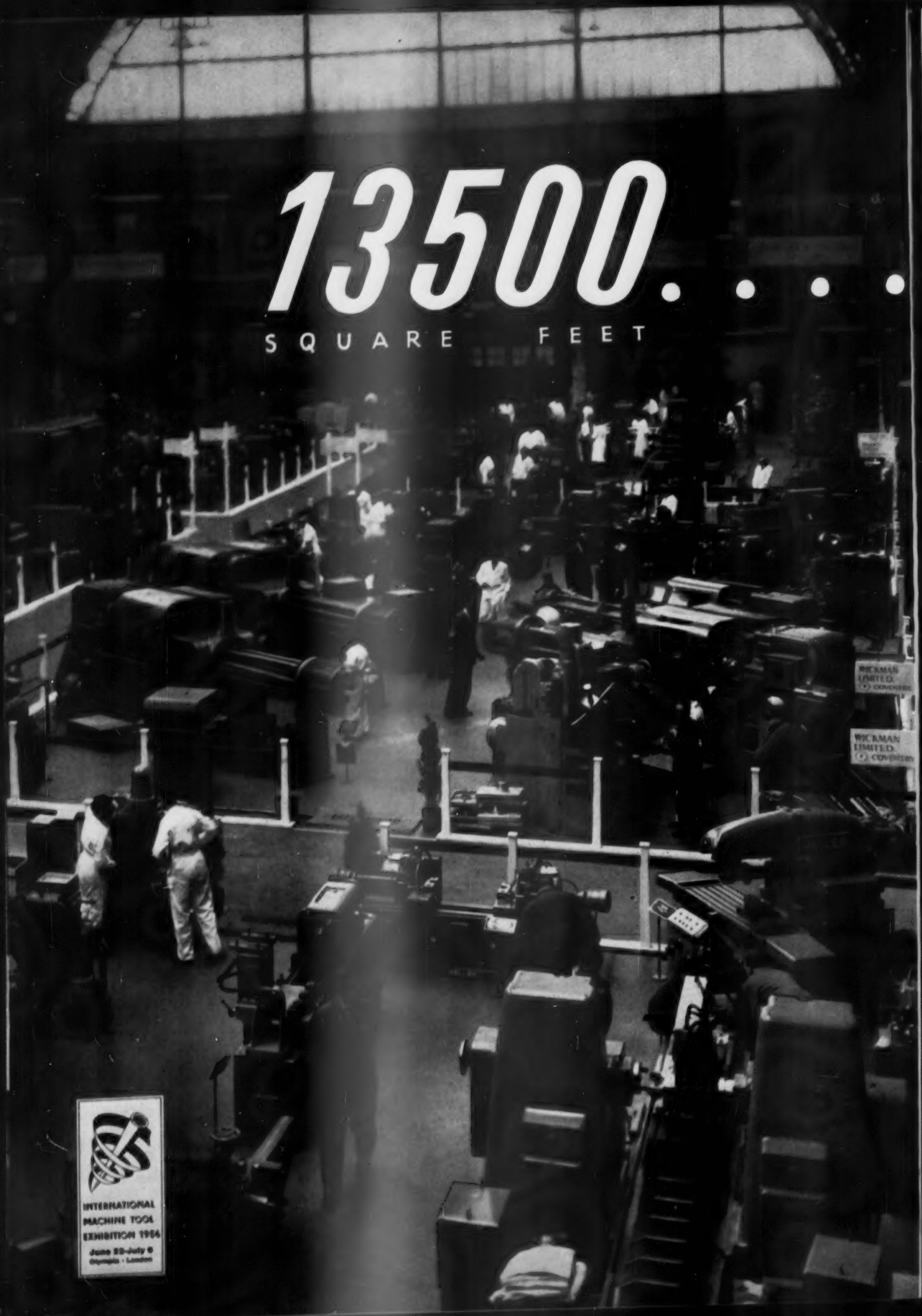
Alas, alack, there are indeed. Indeedy yes!

The right tool? I am glad you asked me that! It is the Desoutter Pneumatic Rackfeed Drill which you *clamp* into position and operate simply by twiddling the small handle between the thumb and the forefinger. Send at once for exciting art photographs (Genuine students only).

THE NEW RACKFEED DRILL BY Desoutter

Desoutter Bros. Ltd. The Hyde, Hendon, N.W.9 Telephone: Colindale 6346 (5 lines) Telegrams: Despnuco, Hyde, London

CRC272


13500. . . .
SQUARE FEET
WICKMAN LIMITED COVENTRY
INTERNATIONAL
MACHINE TOOL
EXHIBITION

to display biggest ever

Wickman

exhibit

The Wickman exhibit at this year's International Machine Tool Exhibition will be the largest ever presented by the Company.

Covering 13,500 square feet of stand space and including over one-hundred machine tools in addition to a wide selection of ancillary equipment, the Wickman exhibit will demonstrate the latest techniques in metal-cutting, grinding and honing, forging, and sheet-metal forming.

In tune with to-day's needs, high production is the key dominating the demonstrations which will be a continuous feature of the show, with something to make everyone's visit worthwhile. Be sure to visit us.

WICKMAN LIMITED

MACHINE TOOL DIVISION · BANNER LANE · COVENTRY

Where to go and what to see —

STAND 112
National Hall

Wickman Automatics.
Wickman Optical Profile Grinding Machines.
Wickman Erodomatics.

STAND 118
National Hall

Carlstedt Deep-Hole Boring Machines.
Collet & Engelhard Horizontal Boring Machines.
Duchscher-Wecker Hammering Machines.
Eumuco Forging Equipment.
Heller Milling Machines.
Herlan Extrusion Presses.
Klopp Shaping Machines.
Kopp Profile Milling Machines.
Lorenz Gear Shaping & Hobbing Machines.
Maypres Toggle Presses.
Nagel Honing Equipment.
Naxos-Union Grinding Machines.
Pines Tube Benders.
Tibo-Yoder Tube Mills and Roll Forming Equipment.
Weingarten Presses.
Weipert Lathes.
Wickman-Moulton Thread Milling Machines.

STAND 119
National Hall

Davenport Multi-spindle Automatics.
Warner & Swasey Chucking Lathes.

STAND 110
National Hall

Losenhausenwerk Balancing and Testing Equipment.

STAND 318
Grand Hall Gallery

Wimet Tungsten Carbide Tools.
Wickman Tool Grinding Equipment.
Neven Metal-Bonded Diamond Wheels.
Spedia Resinoid-Bond Diamond Wheels.
Wickman Cinema.

STAND 525
Empire Hall Gallery

Cary Inspection Equipment.
Dubied Copying Lathes.
Etamic Gauging Equipment.
Habib Tool Grinders.
Hauser Jig Boring & Jig Grinding Machines.
Lambert Precision Gear Hobbers.
Mipsa Grinding Machines.
Ortlieb Tap, Die and Drill Grinding Machines.
Safag Clock and Precision Instrument Manufacturing Equipment.
Schaublin High Precision Lathes and Milling Machines.

STAND 641
Empire Hall Gallery

Wickman Administration and Reception Offices.

Also

STAND 32
Grand Hall

Planers (Huddersfield) Ltd.
Planing Machines.

STAND 111
National Hall

Webster & Bennett Boring & Turning Mills.

STAND 120
National Hall

Arthur Scrivener Ltd.
Centreless & Surface Grinding Machines.

STAND 414
National Hall Gallery

Heenan & Froude Ltd.
Wire and Strip Forming Machines.

445W

"Healthy

Perlift automatic vapour degreasing is absolutely safe ; there is no danger to the operator.

Wealthy

Perlift is economical. Total enclosure conserves trichlorethylene and fully automatic operation cuts labour costs.

and Wise"

Perlift is a wise choice, eliminating possibility of human error and speeding output.

that's TRICHLORETHYLENE DEGREASING by PERLIFT

The Perlift is fully enclosed and consists of an evaporating tank with a thermostatically controlled electric heating system, a vapour chamber and an electrically operated platform hoist. Operation consists of placing work on the platform and pressing the starting button.

Completion of degreasing is denoted by automatic opening of the sliding door and a bell signal.

PERLIFT *Automatic* DEGREASING

The Perlift is available in 3 sizes.

Platform Size	No. 1	No. 2	No. 3
Length/in.	40	60	80
Width/in.	20	25	25
Height/in.	20	27	29
Solvent Volume/gal.	3¼	5¼	6¼

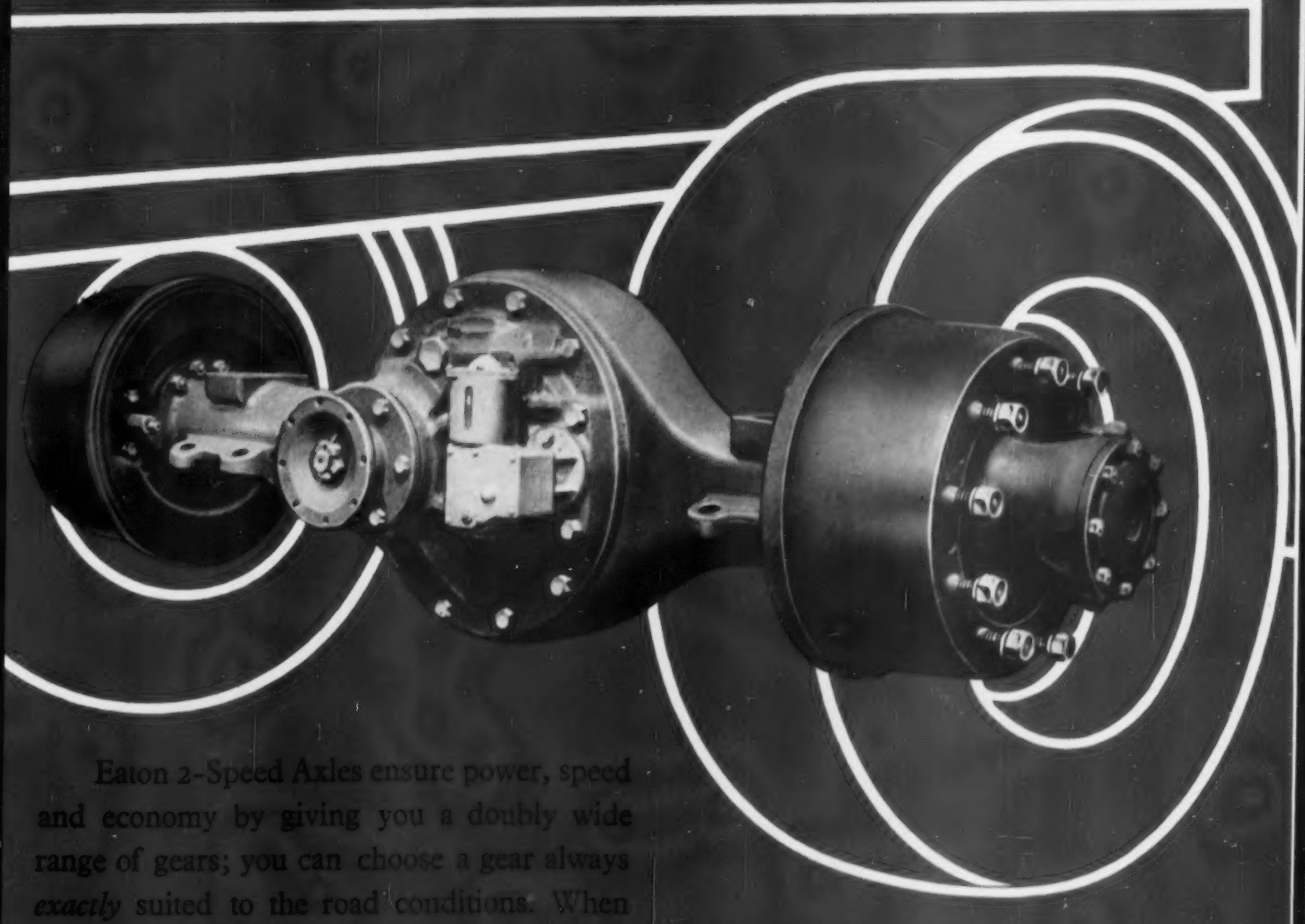
Visit our STAND No. 18, ROW F, at the Production Exhibition, Grand Hall, Olympia

EFCO

ELECTRO - CHEMICAL ENGINEERING CO. LTD.
NETHERBY, QUEENS ROAD, WEYBRIDGE, SURREY · *Weybridge 3891.*

Associated with Efco Ltd., Electric Furnace Co. Ltd., Electric Resistance Furnace Co. Ltd.
Rainbow

POWER SPEED & ECONOMY



Eaton 2-Speed Axles ensure power, speed and economy by giving you a doubly wide range of gears; you can choose a gear always *exactly* suited to the road conditions. When you need power, there is a specially low gear to give it; when road conditions allow easy running, there is the equivalent of an overdrive. And obviously an engine always running at its most effective speed gives you real economy, and will lower your costs for fuel and maintenance.

EATON

2-Speed AXLES

EATON AXLES LIMITED

In association with

EATON MANUFACTURING COMPANY, CLEVELAND, OHIO, U.S.A. E.N.V. ENGINEERING CO. LTD., LONDON, N.W.10 RUBERY OWEN & CO. LTD., DARLASTON

VICTORIA ROAD, WARRINGTON, ENGLAND


K E
THERMAL FATIGUE
RESISTING STEELS
FOR DIE-CASTING, EXTRUSION, STAMPING & FORGING
HOT WORKING TOOL STEELS
IN ULTRASONICALLY TESTED
FORGINGS...
Our recent developments in this field are the result of careful research by our Technical Staff into the call for increased productivity. Should you wish for details of our specialities please notify us so that we may arrange for one of our Technical Representatives to call upon you.
KAYSER ELLISON & CO. LTD.
CARLISLE STEEL WORKS · SHEFFIELD · ESTABLISHED 1825

AMP solderless wiring systems for automation

ELIMINATE REJECTS

LOWER ASSEMBLY COSTS

AUTOMATIC OR MANUAL APPLICATION

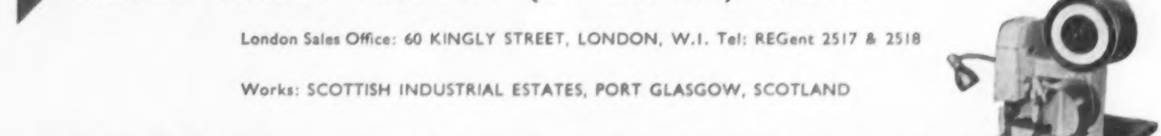
AMP terminals are made for every type and size of wire

Brochure A.E.U. sent, or demonstration at your own Works on request

AIRCRAFT-MARINE PRODUCTS (GT. BRITAIN) LIMITED

London Sales Office: 60 KINGLY STREET, LONDON, W.1. Tel: REGent 2517 & 2518

Works: SCOTTISH INDUSTRIAL ESTATES, PORT GLASGOW, SCOTLAND



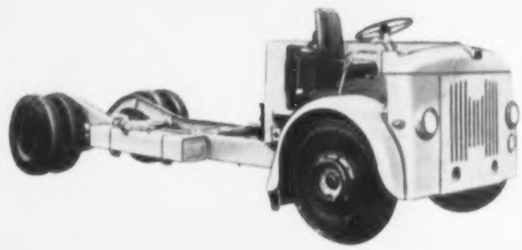
AP 323-11

Leyland

CAPASCO

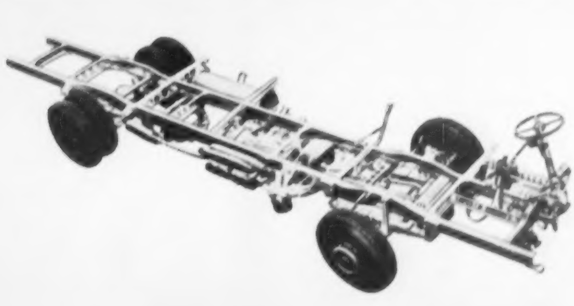
NON-FADE MOULDED
BRAKE LININGS

Leyland now fit Capasco high friction non-fade moulded brake linings on these three famous chassis



TITAN

TIGER CUB



ROYAL TIGER WORLDMASTER

THE CAPE ASBESTOS CO. LTD 114-116 Park Street · London, W.1

Telephone: GROsvenor 6022

M.P.L. have produced a booklet setting out the nature of the sintered metal process and the application of its products within industry. It is a technically informative, well illustrated work which provides an excellent introduction to this important development in powder metallurgy. Design Engineers are invited to request a copy of M.P.L. publication No. 61

Sintered Metallic Components by Machine Products Limited

By employing an extremely advanced technique, Machine Products Limited are able to supply British industry with precision sintered metallic components of superior strength and heavy duty durability — in an almost infinite variety. MPL components are favourably comparable to equivalent piece parts produced by machining from the solid and it is here that the major economy is offered. For, by cutting down appreciably the amount of machining required, MPL sintered metallic components provide industry with an excellent means of effecting a substantial release of capital plant.

MPL

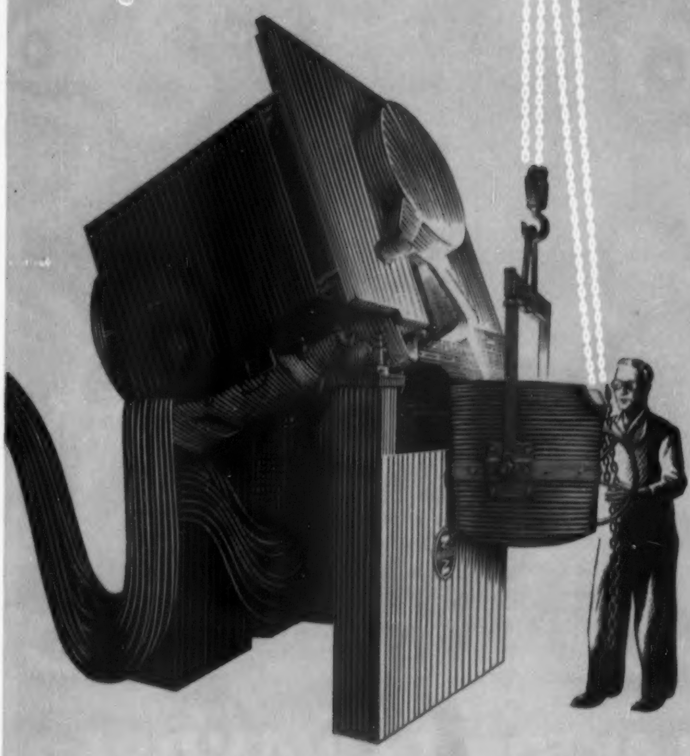
machine products limited

Kembrey Street, Swindon, Wilts.

One of the Plessey Group of Companies

M.P.L. I

Mains Frequency Coreless Induction Melting



For a wide variety of metals and alloys BIRLEC coreless induction furnaces, operated at mains frequency, offer the most efficient known method of re-melting swarf and other finely divided scrap. The unit shown, in operation at the Coventry works of the BRITISH PISTON RING COMPANY LIMITED, is the first furnace of this type to be designed and built in Great Britain and is used to melt fine borings. If you wish to receive further details, please detach this advertisement and send it to BIRLEC LIMITED, adding your

Name..

Position.......................................

Company Address...............................

....

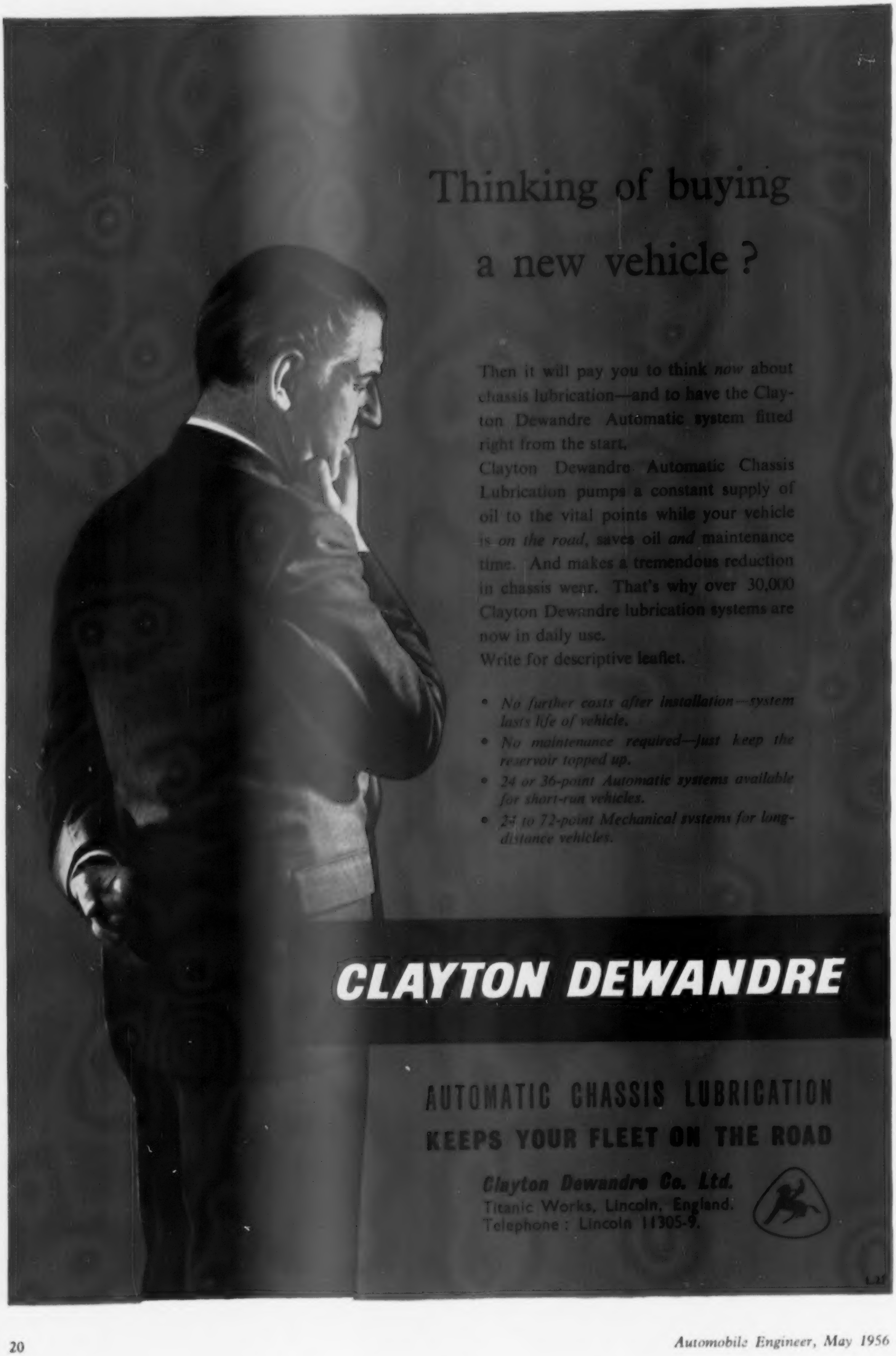
BIRLEC

Member of the A.E.I. Group of Companies.

Birlec Limited

TYBURN ROAD · ERDINGTON
BIRMINGHAM · 24

SM/B2677M/55


Thinking of buying a new vehicle ?
Then it will pay you to think *now* about chassis lubrication—and to have the Clayton Dewandre Automatic system fitted right from the start.
Clayton Dewandre Automatic Chassis Lubrication pumps a constant supply of oil to the vital points while your vehicle is *on the road*, saves oil *and* maintenance time. And makes a tremendous reduction in chassis wear. That's why over 30,000 Clayton Dewandre lubrication systems are now in daily use.
Write for descriptive leaflet.
• *No further costs after installation—system lasts life of vehicle.*
• *No maintenance required—just keep the reservoir topped up.*
• *24 or 36-point Automatic systems available for short-run vehicles.*
• *24 to 72-point Mechanical systems for long-distance vehicles.*
CLAYTON DEWANDRE
AUTOMATIC CHASSIS LUBRICATION
KEEPS YOUR FLEET ON THE ROAD
Clayton Dewandre Co. Ltd.
Titanic Works, Lincoln, England.
Telephone : Lincoln 11305-9.

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

G. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

Heat where you want it

Use electricity and bring the heat to the job instead of having to bring the job to the heat. Heat can be applied wherever it is possible to bring a pair of wires—and so the heating process can be right in the line of production.

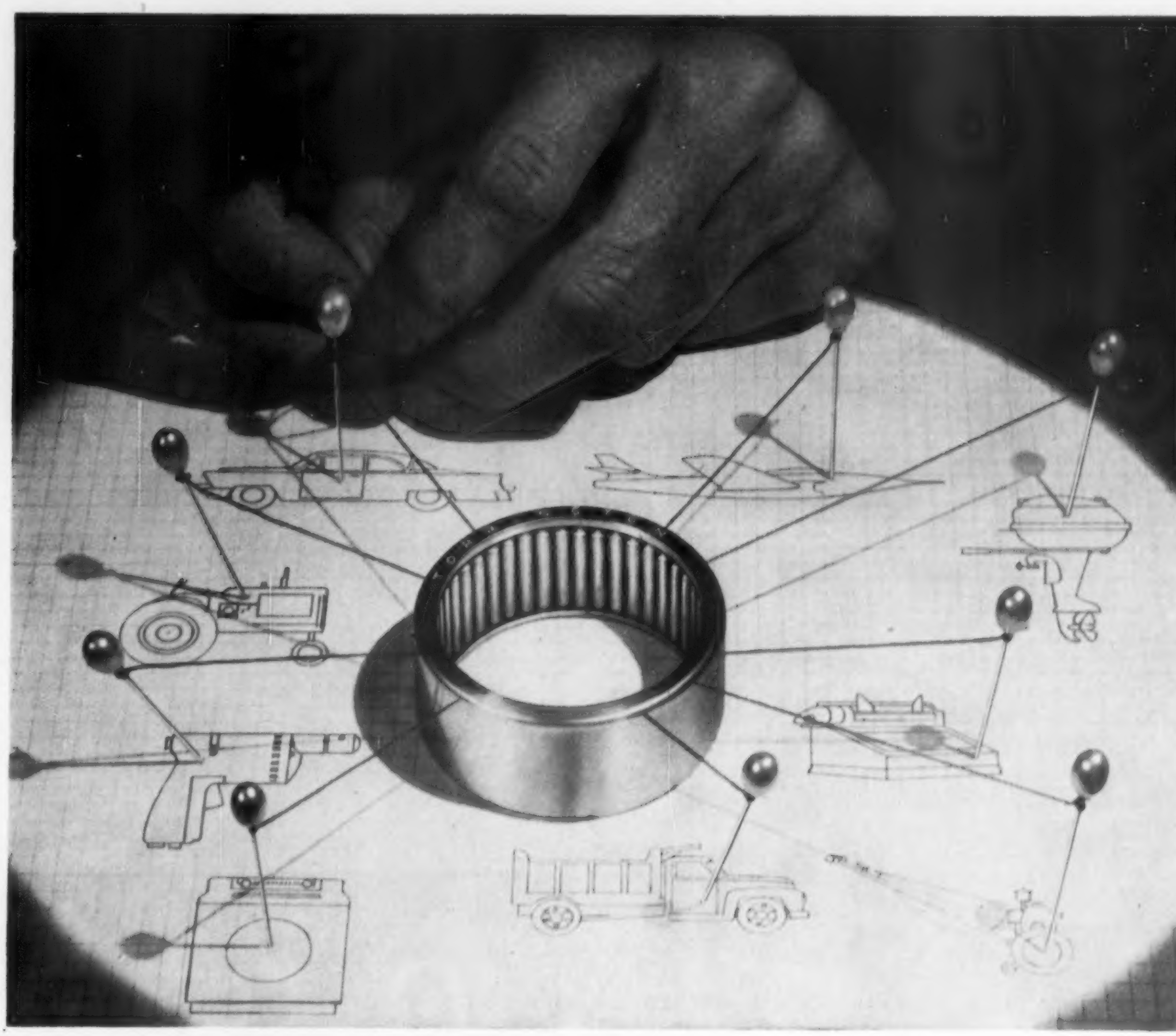
You get much finer control with electricity, too. Temperatures can be controlled automatically—and the constant heat value of electricity means that you know that the treatment is precisely what is required. Not only temperatures but the operation of a complete heating unit can be controlled automatically. Electric heating equipment can be arranged to start, run and shut down to any process requirement or time and temperature cycle.

Heat where you want it, perfect control, cleanliness, lower labour costs and better working conditions are some of the advantages of using electricity for heating. *Heating is just one of the many ways in which electricity plays a vital part in the drive for greater productivity.*

Electricity increases Productivity

Ask your ELECTRICITY BOARD for advice and information, or get in touch with E.D.A. They can lend you, without charge, films about the uses of electricity in industry. E.D.A. are also publishing a series of books on Electricity and Productivity. Titles now available are: Electric Motors and Controls, Higher Production, Lighting in Industry, Materials Handling, and Resistance Heating. Price 8/6 or 9/- post free.

Issued by the
British Electrical Development Association
2 Savoy Hill, London, W.C.2



The TORRINGTON Needle Bearing is Versatile

Wherever the Torrington Needle Bearing is put to work, its unique combination of high radial load and small size enables designers and manufacturers to make their products stronger, lighter and more compact. That's why this versatile bearing has become "standard equipment" in thousands of products throughout industry. In the twenty years that the Needle Bearing has been made, Torrington's Engineering Department has accumulated many lifetimes of experience in adapting the bearing's advantages to products as diverse in size and use as adding machines and tractors. We are always glad to make this experience available to you. *It can be obtained nowhere else.* We invite you to put your bearing problems to our Bearings Division.

TORRINGTON *NEEDLE* **BEARINGS**

NOW AVAILABLE FROM OUR ENGLISH FACTORY

THE TORRINGTON COMPANY. Works: Torrington Avenue, Coventry
London Office: 7-10 Eldon Street, EC2. Glasgow Office: 14 Moir Street, C1

THESE features make the TORRINGTON NEEDLE BEARING unique

- ★ *Low coefficient of starting and running friction*
- ★ *Full complement of rollers*
- ★ *Unequalled radial load capacity*
- ★ *Low unit cost*
- ★ *Long service life*
- ★ *Compactness and light weight*
- ★ *Runs directly on hardened shafts*
- ★ *Permits larger and stiffer shafts*

ΦB

Photograph by courtesy of 'Motor Racing'

The fastest T.T. of all time! Stirling Moss comes home first in the R.A.C. International T.T. at Dundrod — with an average speed of 88.32 m.p.h. Well done, Stirling Moss and Mercedes!

Brilliant driving by Wharton. With BP Super in the tank of his Ford Zephyr, Ken Wharton was placed first in the 2001 to 3000 c.c. class in the Production Touring Car Race at the Daily Express Trophy meeting at Silverstone.

Photograph by courtesy of 'The Autocar'

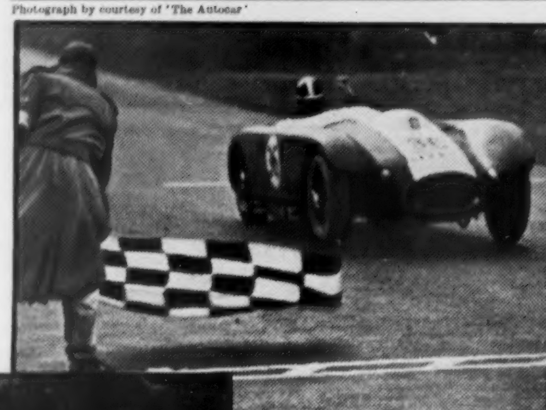
A YEAR OF VICTORIES FOR BP SUPER

From Silverstone to Sweden, this outstanding petrol had a remarkable winning record in the year's big races

At Silverstone, at Dundrod in Ulster, at Oulton Park and Brands Hatch, at Kristianstad in Southern Sweden, the leading drivers of 1955 battled for victory in some of the world's most exacting races — and the cars that won were fuelled on BP Super.

These successes show what superb performance you can get from a super petrol. Whatever type of car you run, and whatever kind of motoring you go in for, from races and rallies to everyday driving in town and countryside, BP Super gives your engine more 'zip', smoother acceleration and greater freedom from engine-knock. What is more, it gives you more miles per shilling, too.

Big wins in last year's big races have proved the worth of BP Super under the most testing conditions a motorist could encounter. You can see what they mean when they call BP Super 'the petrol with more energy per gallon'!



Photograph by courtesy of 'The Autocar'

Here comes another BP Super-man! W. A. Scott-Brown used BP Super in his two-litre Lister-Bristol and won the British Empire Trophy for sports cars — besides many other races during the season.

Some of the big wins on BP Super during the 1955 season

Ulster T.T. 1st. Stirling Moss. 2nd and 3rd. J. M. Fangio and G. von Tripps. All driving Mercedes cars.

R.A.C. Rally of Great Britain. 1st. J. Ray and B. Horrocks, Standard. 3rd. K. Richardson and J. Heathcote, Standard. Team award — Standard team and three class wins.

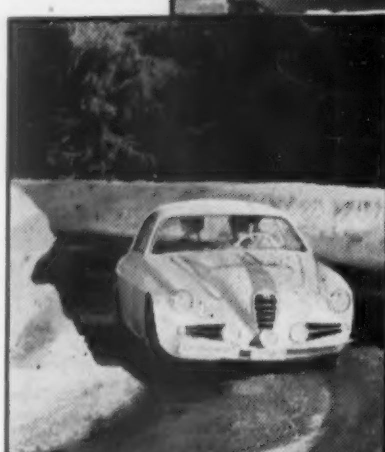
Silverstone Production Touring Car Race. 2001-3000 c.c. class. 1st. Ken Wharton in a Ford Zephyr.

Tulip Rally. 1st. W. J. J. Tak in a Mercedes.

British Empire Trophy. 1st. W. A. Scott-Brown in a Lister-Bristol.

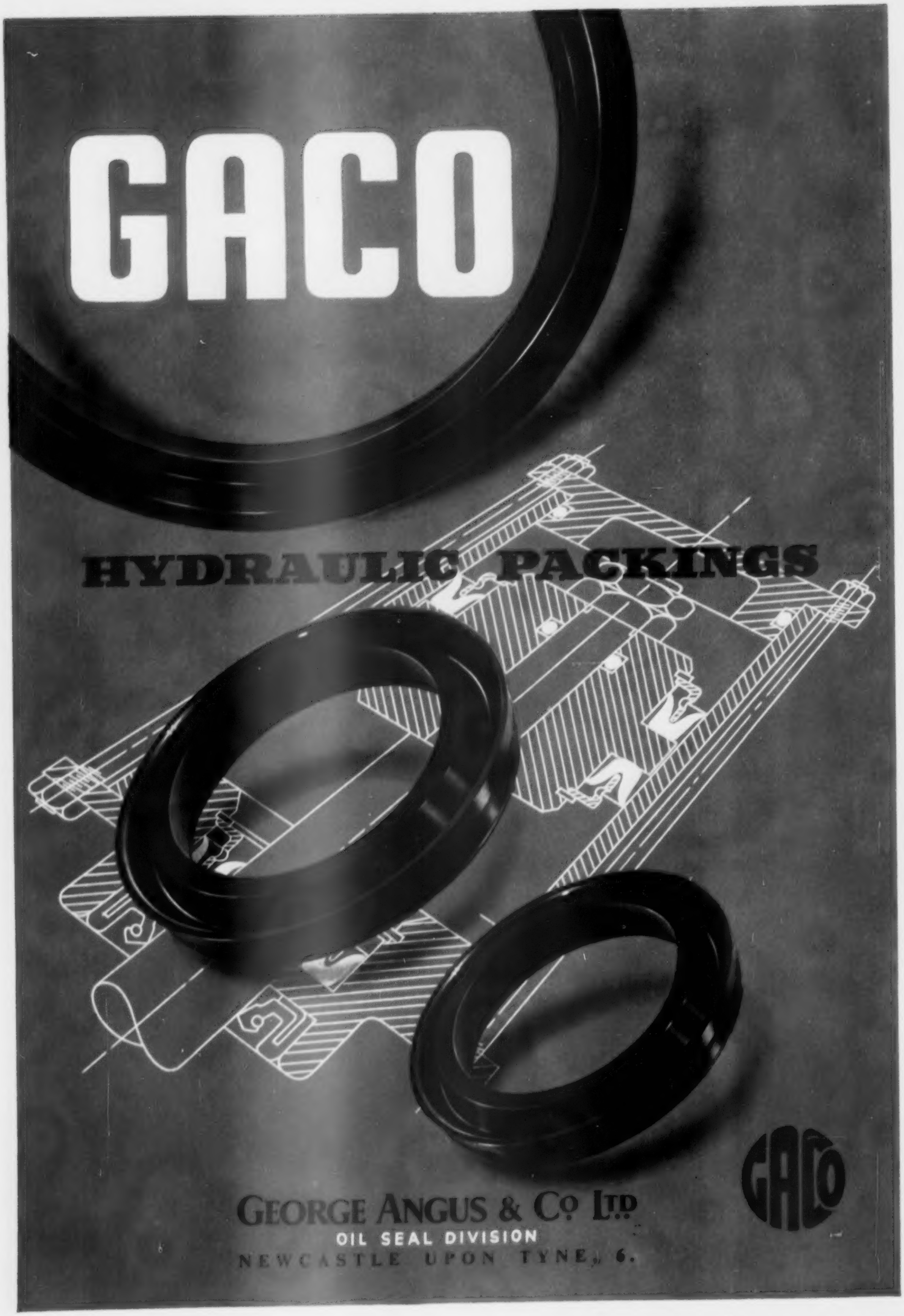
Swedish Grand Prix. 1st. J. M. Fangio. 2nd. Stirling Moss. Both driving Mercedes cars.

Lyons-Charbonnières Rally. Outright Winner — Houel, in an Alfa-Romeo. First four places in general classification. Five firsts out of six other class events.

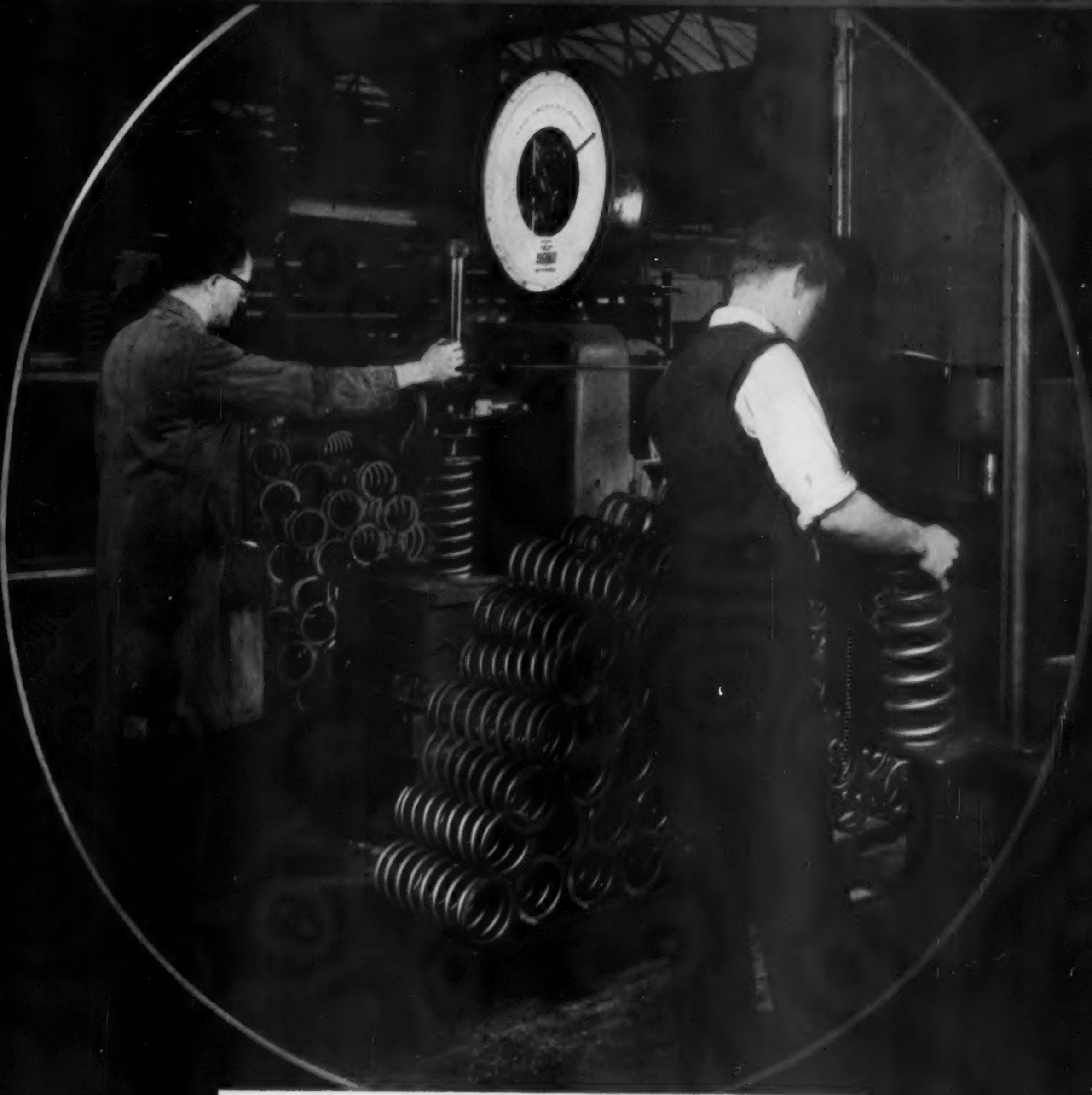


First four places on BP Super. In the important Lyons-Charbonnières Rally the first four places in the general classification were won on BP Super. So were five firsts out of six other class events. Here is Houel, the outright winner, in his Alfa-Romeo — in which he used both BP Super petrol and BP Energol motor oil.


OAKENSTRONG
OAKENCORK
OIL and PETROL
GASKET MATERIALS
DISTRIBUTORS OF MATERIAL IN BULK FOR GT. BRITAIN
J.A. NORDBERG LTD
171 QUEEN VICTORIA ST., LONDON, E.C4.
Tel: Central 9678
REGISTERED
TRADE MARK
FOREIGN & COLONIAL ENQUIRIES TO
H. JACKSON LTD
OAKENCLOUGH, GARSTANG Nr. PRESTON LANCS.
Tel: Garstang 8


GACO
HYDRAULIC PACKINGS
GACO
GEORGE ANGUS & CO LTD
OIL SEAL DIVISION
NEWCASTLE UPON TYNE, 6.

SILICO-MANGANESE SPRING STEEL

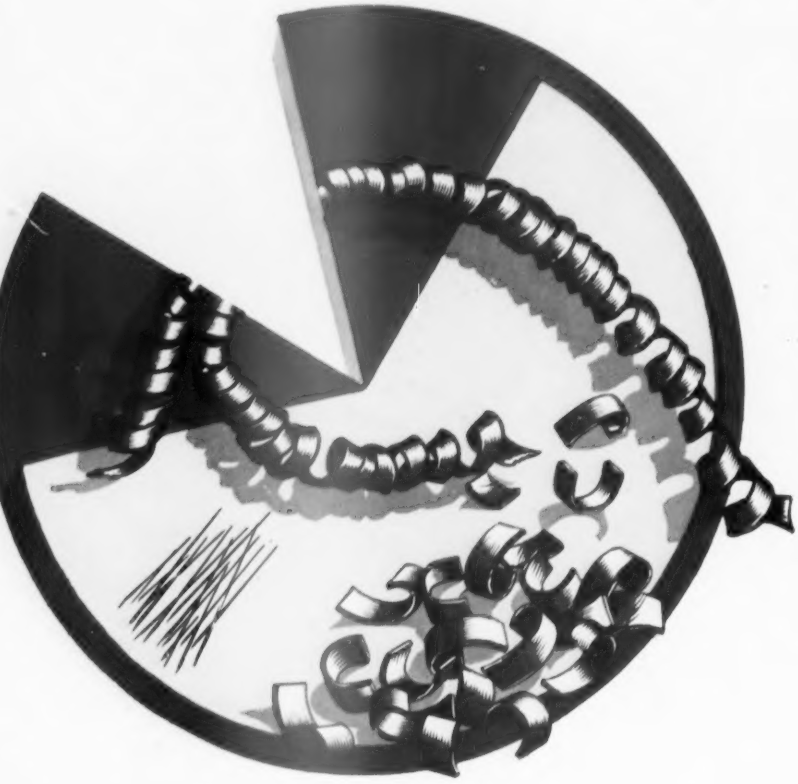


At The Bramber Engineering Company Ltd.; scrag-testing and checking deflection rate of coil springs made from RTB spring steel.

RICHARD THOMAS & BALDWINS LTD.,
PANTEG WORKS, PONTYPOOL, MON.
HEAD OFFICE:
47, PARK STREET, LONDON, W.1

RTB

MOLYBDENUM'S PLACE IN INDUSTRY



DO YOU MAKE MANY OF THESE?

By-products of essential operations, they comprise long curling shavings from twist drills, chips from other tools, rough needle-like swarf from milling cutters, barely perceptible gleanings from the reamers.

THEY HAVE TWO FACTORS IN COMMON

FIRST: the steel you are machining may itself contain Molybdenum—for more than 500,000 tons of the alloy constructional steel made in Britain last year for highly stressed parts such as some parts of automobiles, were alloyed with MOLY.

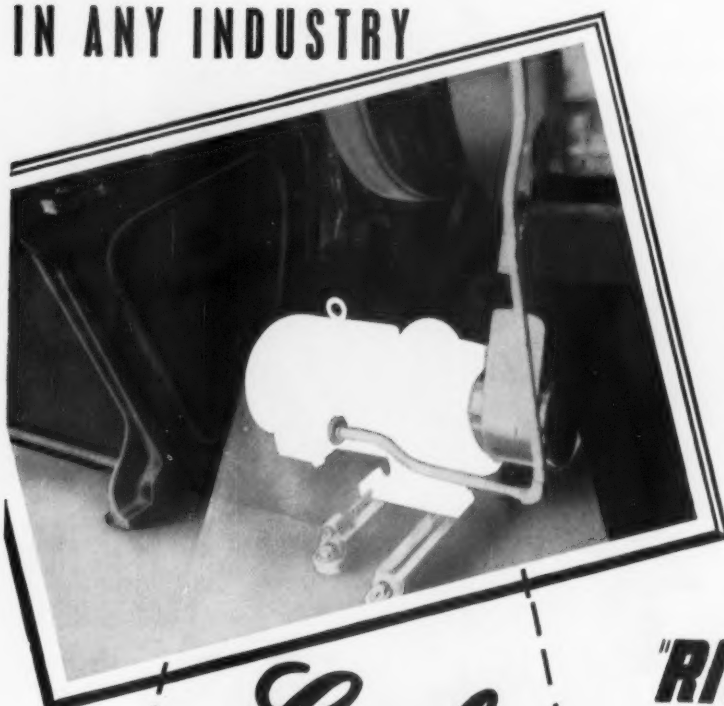
SECOND: the swarf may have been produced by high speed steel tools containing Molybdenum, which is being used to an increasing extent in this country, (in the United States 80-90% contain Molybdenum).
On both counts you can rely on Molybdenum, which for more than 10 years has been free from violent price fluctuation.

YOU CAN PIN YOUR FAITH TO **MOLY**

PRONOUNCED 'MOLLY'

CLIMAX MOLYBDENUM COMPANY OF EUROPE LIMITED, 99 PINSTONE STREET, SHEFFIELD, 1

IN ANY INDUSTRY

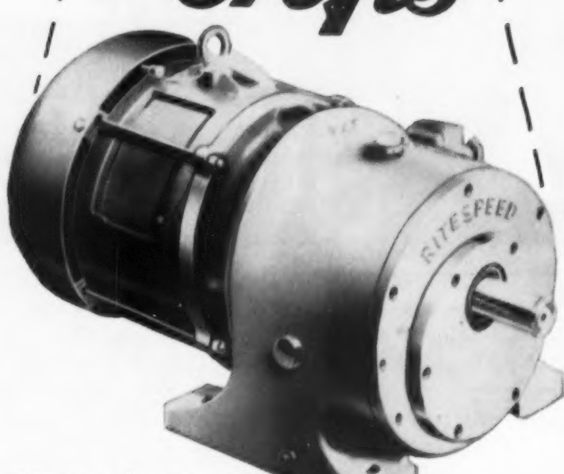


"Ritespeed" Geared Motor Drive applied to a Dyeing Vat.

TYPICAL INDUSTRIAL USES

FOOD PROCESSING MACHINERY
TEXTILE MACHINERY
CHEMICAL PLANT
PAINT MAKING MACHINERY
MILLING MACHINERY
LAUNDRY MACHINES
PRINTING & BOXMAKING PLANT
CONVEYORS
MACHINE TOOLS
MECHANICAL STOKER DRIVE

Crofts



"RITESPEED" GEARED MOTORS AND REDUCTION GEARS COMPLETE THE PICTURE

Any combination of motor, gear ratio and mounting position can be supplied. Units up to 20 H.P. are available from stock, larger sizes on quick delivery. Ratios up to 82-1.

For details see Pub. No. 5329, 5330/1

POST FOR YOUR COPY **NOW!**

Crofts (ENGINEERS) LIMITED. BRADFORD 3. ENGLAND
PHONE 65251 (15 LINES) GRAMS - "CROFTERS BRADFORD"

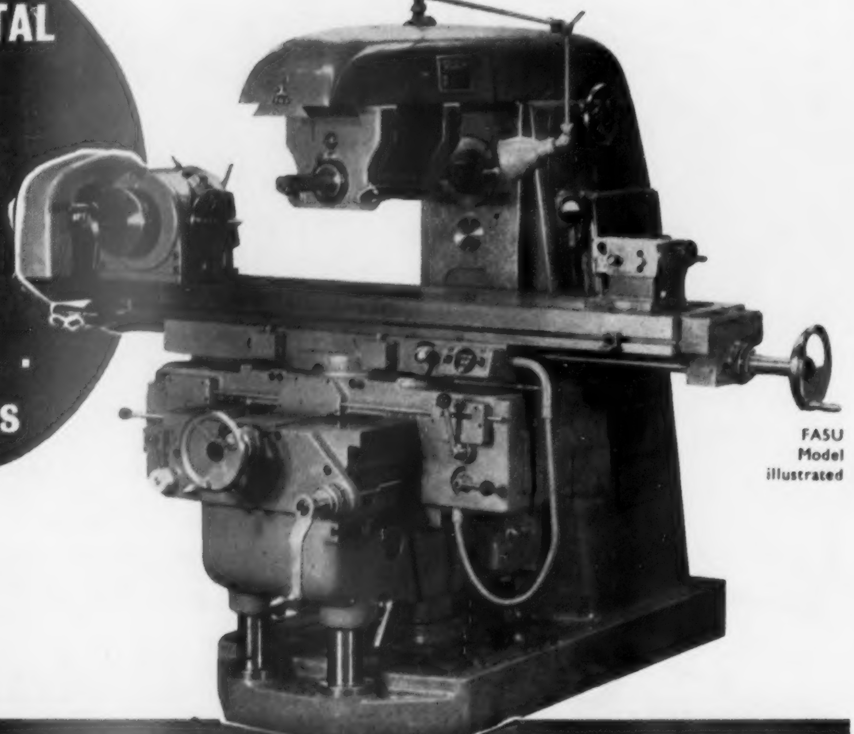
183

HORIZONTAL

UNIVERSAL

VERTICAL

All sizes . . .
. . all types



FASU
Model
illustrated

ZBROJOVKA MILLERS

Early delivery of all models from London stock

BRIEF SPECIFICATIONS				
FOUR SIZES	No. 2	No. 3	No. 4	No. 5
Working surface of table (approx.)	40" x 8"	50" x 10"	64" x 12"	80" x 16"
Power longitudinal travel (approx.)	25"	32"	40"	50"
Power cross travel (approx.)	8"	9"	12"	16"
Spindle Speeds	63-2800	45-2000	32-1400	18-1400

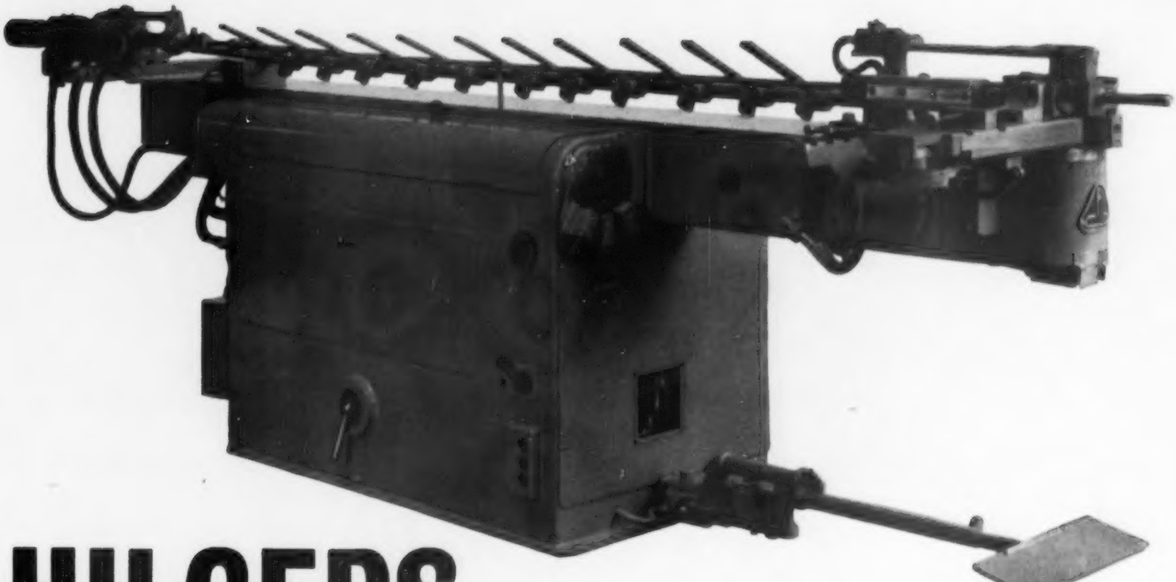
SOLE AGENT

Selson
MACHINE TOOLS

The Selson Machine Tool Co. Ltd

CUNARD WORKS, CHASE ROAD, NORTH ACTON, LONDON, N.W.10
Telephone: Elgar 4000 (10 lines)   Telegrams: Selsomachi, London

THE 600 GROUP



HILGERS

Automatic and semi-automatic
TUBE BENDING MACHINES

The complete range of Hilgers Semi-Automatic and Automatic Tube Bending Machines is suitable for both right and left hand bending, and working speed is infinitely variable. When the machine is adjusted to lowest working speed the return movement always switches automatically to the highest return speed. Moving parts are completely enclosed and lubricated automatically by a central system, thereby cutting maintenance to the minimum. Many of these excellent machines can be seen in operation in the United Kingdom.

BRIEF SPECIFICATIONS

Type HE.38 Semi-Automatic Cold Tube Bending Machine with Combined Mechanic Hydraulic Drive.

Largest tube diameter approx. 1½" o.d. x 14 s.w.g. thick
Number of bends per hour......................up to 250

Types HYB.50 & HYB.70 Hydraulic Automatic Cold Tube Bending Machines

	HYB.50	HYB.70
Largest tube diameter	approx. 2" o.d. x 5/64" thick	approx. 2¾" o.d. x 5/64" thick
Number of bends per hour	up to 600	up to 450

Type HDY.114 Semi-Automatic Cold Tube Bending Machine with Hydraulic Operation.

Largest tube diameter
114 mm. o.d. x 5 mm. wall thickness
Number of bends per hour......................up to 400

Selson
MACHINE TOOLS

SOLE AGENTS

The Selson Machine Tool Co. Ltd
CUNARD WORKS, CHASE ROAD, NORTH ACTON, LONDON, N.W.10
Telephone: Elgar 4000 (10 lines) Telegrams: Selsomachi, London
THE 600 GROUP

This is the AZOFLEX Model 42/63 Mark II Combine Printing and Developing Machine. Designed to be handled by one *unskilled* operator, it can be run at speeds ranging from 6 inches to $15\frac{1}{2}$ feet per minute with any of the wide range of AZOFLEX photo-printing materials to give a continuous output of first-quality prints from drawings, plans and other originals up to a maximum width of 40 inches. Special features of the machine include a suction feed device, controlled cooling of the exposing cylinder, patented micro-grooved rollers to ensure perfect development at all operating speeds, and complete synchronization of the exposing, developing and print delivery units. Dry, flat prints, ready for immediate handling, are produced with the minimum of trouble—there is no mess or smell and special darkroom accommodation with water and drainage services is not required.

ILFORD *Azoflex*

There is a comprehensive range of AZOFLEX machines and materials to meet the requirements of every type of organization. For descriptive literature, please apply to Ilford Limited, Azoflex Department **AZ5V**, 104 High Holborn, London, W.C.1. (Tel.: HOLborn 3401). Demonstrations of the Azoflex process can be seen at the above address and also, by appointment, at Ilford Limited, 22 Lloyd Street, Manchester, 2. (Tel.: Deansgate 4233) and in other principal cities.

PHOTO · PRINTING MACHINES AND MATERIALS


THE
GLOSTER
JAVELIN
USES
HOFFMANN
BALL AND ROLLER
BEARINGS
Yes, you are looking at the rear end of a Gloster Javelin speeding away from you. Its two Armstrong Siddeley Sapphires are well jewelled with Hoffmann Bearings, meeting the stringent conditions of load, speed and temperature.
THE HOFFMANN MFG. CO. LTD.,
CHELMSFORD ESSEX, ENGLAND

Photograph by courtesy of Ford Motor Company Limited

When safety is vital, and efficiency must never be in doubt, the ability of a nut to stay put is of paramount importance. Ford Motor Company Limited choose Philidas.

Fit PHILIDAS Self-locking Nuts

the nuts that stay put

Philidas Division of Whitehouse Industries Ltd., Ferrybridge, Yorks. Tel. Knottingley 320.
London Office: 6 St. James's Place, S.W.1. Tel. Hyde Park 9248/9.

PH/CON/56

Self-locking nuts, for the Automobile, Aircraft, Electrical and Engineering Industries. Wheel Nuts, Anchor Nuts, Strip Nuts, etc.

A TURN TO THE RIGHT . . .

At the next corner, or the next-but-one, our lady driver will turn to the right (or will it be the left?) taking steel with her in a multitude of forms. Body work, chassis, engine, the wheel she holds, the foot pedals she sometimes uses and many other components are made from steel—more often than not, Steel by LEE. Our daily output of cold rolled strip, bright drawn bars and "Trubrite" stainless steel feed the production lines of leading automobile, motor cycle, and bicycle manufacturers. Limited only by the fields in which steel is used, LEE'S products feature extensively in well-known domestic appliances, cutlery, and kitchen equipment manufacture, shipbuilding yards and aircraft plants, etc., to name but a few. A word about steel with LEE of SHEFFIELD will be a turn to the right.

LEE *of Sheffield*

TRUBRITE

ARTHUR LEE & SONS LIMITED

HEAD OFFICE AND WORKS: TRUBRITE STEEL WORKS · MEADOW HALL · NEAR SHEFFIELD

COIL SPRINGS
* COIL SPRINGS
* TORSION BARS
* LAMINATED SPRINGS
also
* UPSET FORGINGS
TOLEDO WOODHEAD SPRINGS
give top performance everywhere
TORSION BARS
also
UPSET FORGINGS
As vehicle suspension engineers we design and manufacture or supply to requirements all types of springs used in automotive design.
We are also the manufacturers of
KANTLINK
SPRING WASHERS
LAMINATED SPRINGS
TOLEDO WOODHEAD SPRINGS LIMITED · SHEFFIELD 3
TWS65

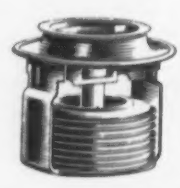

An important feature
NEW
of the CINCINNATI
No. 2 CENTRELESS GRINDER is the mounting
of the LOWER SLIDE ON PRE-LOADED
PRECISION BALL BEARINGS
CINCINNATI
CINCINNATI
THE INFEED DIAL CAN BE ADJUSTED
FOR FINE INCREMENTS OF CUT AND
THE SLIDE WILL MOVE BY PRECISELY
THAT AMOUNT—BECAUSE "STICK-SLIP"
OTHER OUTSTANDING FEATURES OF THIS NEW PRECISION CENTRELESS GRINDER INCLUDE—
AUTOMATIC BALANCING OF THE GRINDING WHEEL
INFINITELY VARIABLE REGULATING WHEEL DRIVE
and, of course, the FILMATIC GRINDING WHEEL SPINDLE BEARINGS
CINCINNATI MILLING MACHINES LIMITED
Birmingham, 24

it's a good plan to include

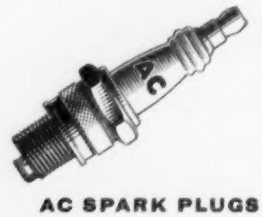
AC-Delco QUALITY PRODUCTS

AC OIL FILTERS

AC AIR CLEANERS AND SILENCERS

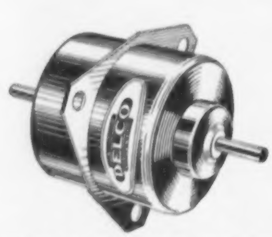


AC THERMOSTATS

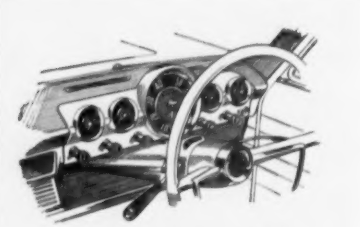


AC SPARK PLUGS

AC FUEL PUMPS



DELCO ELECTRIC MOTORS



AC INSTRUMENTS

Virtually every British car has one or more AC-Delco components designed into it on the drawing-board. AC-Delco research engineers will gladly help when you are planning a new design or modifying an existing one. Liaison at the drawing-board stage can help your design and production programme.

DELCO-REMY IGNITION COILS

These are a few in the wide range of AC-Delco automobile and electrical products.

AC-DELCO DIVISION OF GENERAL MOTORS LIMITED, Dunstable, Beds. Telephone Dunstable 1166
or **Broadgate House, Coventry. Telephone Coventry 40491**

Whether it be an oil, grease, gas, alkali, dilute acid or any other fluid that must be sealed, whether pressures are great or small, or the temperature high or below zero, there is a Dowty Seal to suit your specific requirements.

Our extensive design and research departments are always ready to advise in the selection of the most suitable specification and media for your own particular application.

DOWTY Seals

Member of the DOWTY Group

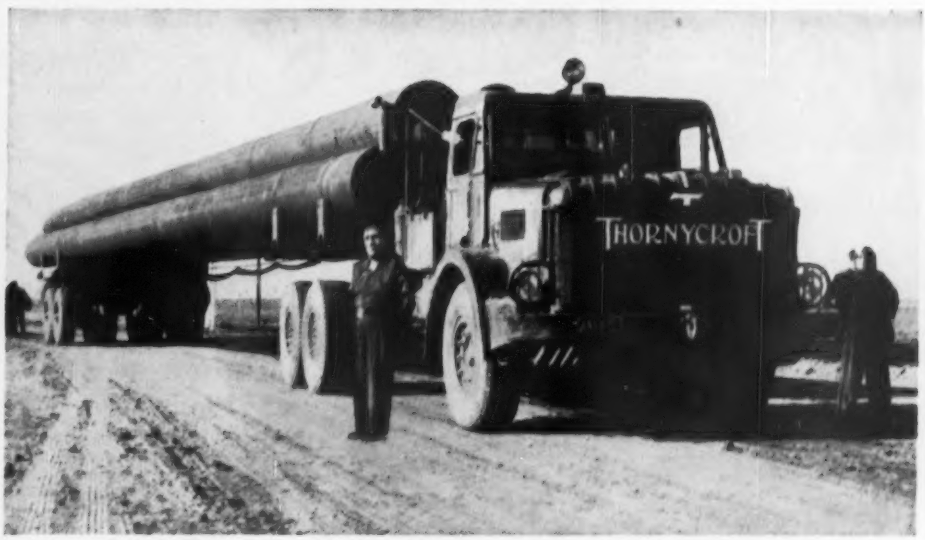
DOWTY SEALS LIMITED · ASHCHURCH GLOS.

Telephone Tewkesbury 2271


THE FULLER R-45
'ROAD RANGER'
FEATURES: 8 progressive ratios, no change exceeding 30%. Fast, simple one-lever shifts. All manual shifts normal, with dog-clutch engagement: synchronized change of 'range' by power shift button on lever. All gears helical, 2 reverse ratios. Compact construction. For engine torque of 385 lb. ft.
NEW
One lever controls 8 forward speeds
Exclusive European
Representatives for the Fuller Manufacturing Company of Kalamazoo, Michigan, U.S.A.
AUTOMOTIVE PRODUCTS COMPANY LTD.
Brock House, Langham Street, London, W.1. England
Telephone: Langham 2527
Fuller
TRANSMISSIONS

KIRKSTALL AXLES

IN USE



LAYING THE PIPE LINE IN IRAQ

KIRKSTALL FORGE ENGINEERING
LIMITED LEEDS, 5

Telephone : Horsforth 2821

F.P.2

AT THE MECHANICAL HANDLING EXHIBITION

and on show all the year round

by FENNER OF HULL

IN ATTENDANCE ON STAND No. 33 AT EARLS COURT

HOME

D. E. ASLEN *(Sales Manager)* ... ... May 9 & 10

I. A. F. MACNAIR *(London Regional Manager)* ... ... May 9, 10, 14, 15, 17, 18

H. L. TITTERINGTON *(North West Regional Manager)* ... May 14, 15, 16, 17, 18

C. S. HANDLEY *(Assistant London Regional Manager)* ... May 11, 12, 16, 17, 19

J. MORGAN *(Newcastle Branch Manager)* ... ... May 9, 10, 11

OVERSEAS

L. J. D. DAVIES *(Sales Manager)* ... ... May 10 & 11

AT THESE FENNER BRANCHES

BELFAST, 35 King Street .... *Belfast* 25409
BIRMINGHAM. V-Belt House, 25 Broad Street, 1 ... *M'Dland* 4505/6
BURNLEY, V-Belt House, 73/77 Manchester Road ... *Burnley* 2258
CARDIFF, V-Belt House, West Wharf Road ... *Cardiff* 25151/2
CLECKHEATON, 92 Whitcliffe Road ... *Cleckheaton* 891/2
GLASGOW, 98 Holm Street, C.2 ....*City* 7136/7
HULL, Marfleet Avenue ....*Central* 13900
LEEDS. 32 Dewsbury Road, 11............*Leeds* 33420
LEICESTER. V-Belt House, 50 Southgate Street ... *Granby* 223
LIVERPOOL. V-Belt House, 42 Great Howard Street ....*Central* 3236
LONDON. V-Belt House, 54 Southwark Bridge Road, S.E.1.................................*Waterloo* 7466/7
LUTON. V-Belt House, 58 Bute Street and 38 Guildford Street .... *Luton* 5089
MANCHESTER. V-Belt House, 454 Chester Road ....*TRAfford Park* 1341
NEWCASTLE-ON-TYNE, 61 Westgate Road ... *Newcastle* 24684
NOTTINGHAM. V-Belt House, 136 Canal Street ... *Nottingham* 41079
SHEFFIELD. V-Belt House, 86 Bridge Street ... *Sheffield* 27774
STOCKTON-ON-TEES. V-Belt House, 18 William Street...............*Stockton-on-Tees* 68064
STOKE-ON-TRENT, V-Belt House, 32 Hartshill Road ....*Stoke-on-Trent* 44587

J. H. FENNER & CO. LTD · HULL

LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH

MADE BY THE PIONEERS
IN PRECISION
STEERING
GEARS

EFFORTLESS STEERING AND GREAT DURABILITY

Hardened cam and roller.
Tapered roller bearings (with detachable cones on the larger sizes).
Double bearing support to rocker shaft.
End-location adjustable.
Larger angular movement.
Very compact box.
For fore-and-aft or transverse layout.
Trunnion or spigot mounting alternative on heavy types.

THE 'MARLES' DOUBLE-ROLLER GEAR, made in a range of sizes covering every type of chassis.

BETTER ROADS
FOR
BETTER LIVING

MARLES

ADAMANT
ENGINEERING CO. LTD., DALLOW ROAD, LUTON
Sole proprietors of the Marles Steering Company Ltd.
Telephone: LUTON 2662 (4 lines). *Telegrams: ADAMANT, PHONE, LUTON*

A leap in the dark!

"'TIS THE ROUNDHEADS, Sir Percy. Haste thee, Milord — jump for it!"

"But 'tis dark outside," said Sir Percy plaintively — off the battlefield he was a man of cautious disposition — "'tis wondering where to jump I am?"

"'Tis no time to ponder" retorted the Squire, "Haste!"

"Very well then, I suppose thou knowest best." Sir Percy grasped his sword, swung his cloak, and leapt into a world of darkness; he was pleasantly surprised to land on something soft and yielding. "Gad!" he beamed, "the age of miracles is not yet past." From beneath him, oddly muffled, the Squire's voice choked; "'Twould be uncommon kind of milord to remove his scabbard from the small of my back."

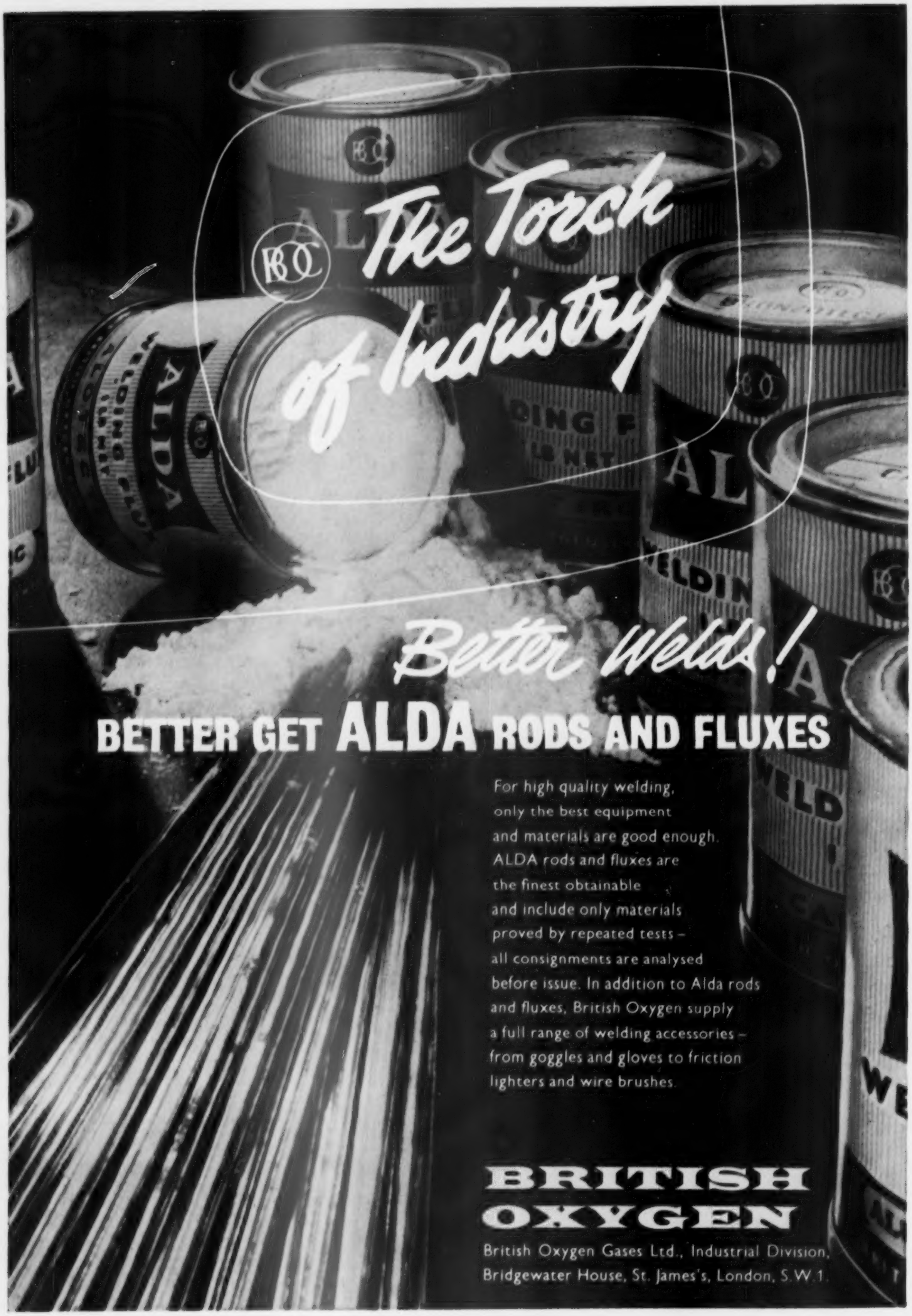
"Faith!" cried the cavalier — "here is a waggish situation indeed. Meseems I made a splendid landing on thy broad and faithful back. And where didst *thou* come to earth, old friend?"

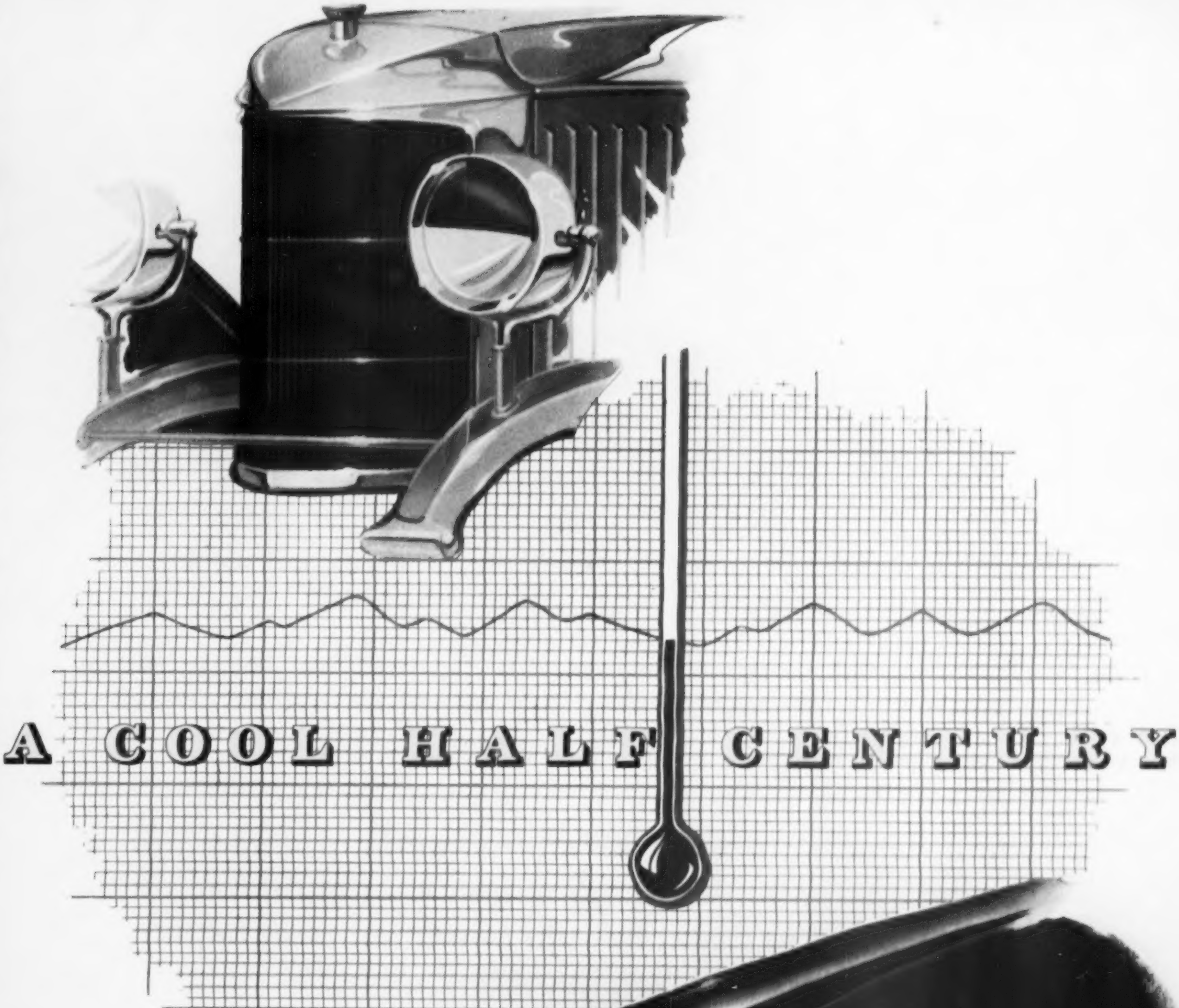
The Squire squirmed uneasily. "Verily I could not swear to it, but if I mistake me not, we are in the cattleyard." His movements were accompanied by an odd squelching sound. "Verily thou wert unfortunate," said Sir Percy with soldierly sympathy — "perhaps that will teach thee the folly of a spring in the dark. And speaking of springs" — he spake with a knowledge surprising in one of that period — "Didst know that the most inferior springs may look exactly like a genuine high precision job, guaranteed for years of high performance? What! not interested in springs? Ah, well, perhaps a tub would suit thee better." He ambled off into the darkness . . .

Advertiser's Announcement

M-W.416

The TRADITION behind MIDCYL
"It's an education"
The craftsmen who built the Midcyl tradition pass on their knowledge and skill to be wedded to the modern methods employed today
THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS.


The Torch of Industry
Better Welds!
BETTER GET ALDA RODS AND FLUXES
For high quality welding, only the best equipment and materials are good enough. ALDA rods and fluxes are the finest obtainable and include only materials proved by repeated tests – all consignments are analysed before issue. In addition to Alda rods and fluxes, British Oxygen supply a full range of welding accessories – from goggles and gloves to friction lighters and wire brushes.
BRITISH OXYGEN
British Oxygen Gases Ltd., Industrial Division, Bridgewater House, St. James's, London, S.W.1.


A COOL HALF CENTURY
CMF
COVENTRY MOTOR FITTINGS
COVENTRY TEL: 3144
RADIATOR SPECIALISTS SINCE 1905

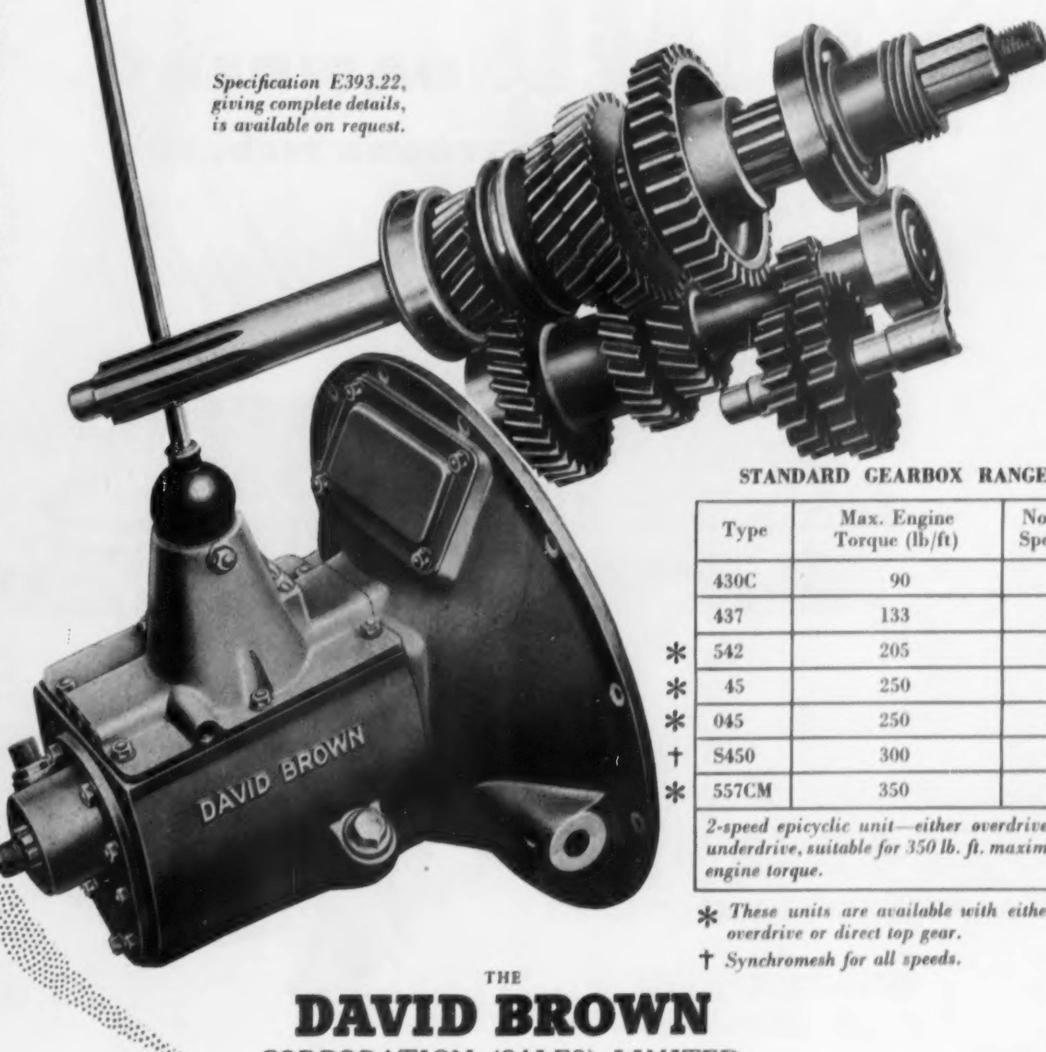

Engineered rubber as a silent partner
EMPIRE RUBBER COMPANY
RUBBER BONDERS LTD
DUNSTABLE, BEDFORDSHIRE, ENGLAND

PROVED IN SERVICE

Smallest in the DAVID BROWN range, the 430C 4-speed Gearbox has proved itself as a completely dependable unit designed for light commercial vehicles up to 25 cwt. capacity.

Outstanding features include quietness and ease of operation, simplicity, sturdiness, low weight to strength ratio and exceptionally short overall length. Here is a compact unit that will fit simply into chassis layouts within its range.

Specification E393.22, giving complete details, is available on request.



STANDARD GEARBOX RANGE

	Type	Max. Engine Torque (lb/ft)	No. of Speeds
	430C	90	4
	437	133	4
*	542	205	5
*	45	250	5
*	045	250	5
†	S450	300	4
*	557CM	350	5
	2-speed epicyclic unit—either overdrive or underdrive, suitable for 350 lb. ft. maximum engine torque.		

* *These units are available with either an overdrive or direct top gear.*

† *Synchromesh for all speeds.*

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEARBOX DIVISION
PARK WORKS HUDDERSFIELD

read

what S.C.H. Davis of 'The FIELD' has to say about The Adjustable

TELAFLO DAMPERS

as fitted to **ARMSTRONG SIDDELEY**

Sapphire
346

. . . . . . unlike some of its predecessors, this control does work. The car will "flow" over any kind of road surface most comfortably and can be adjusted to any load—and all this while running.

Vide "The Field," February 2, 1956

The Adjustable Telaflo Telescopic Damper provides instant ride-control from the driver's seat at all speeds and under all conditions. It will be available in due course for other makes of car.

An Original Product of **ELAFLO LTD**
in association with **UNIVERSAL DAMPERS LTD, SHIRLEY, BIRMINGHAM**
Telephone: SOLihull 4615/8

3855

MORSE

timing chains

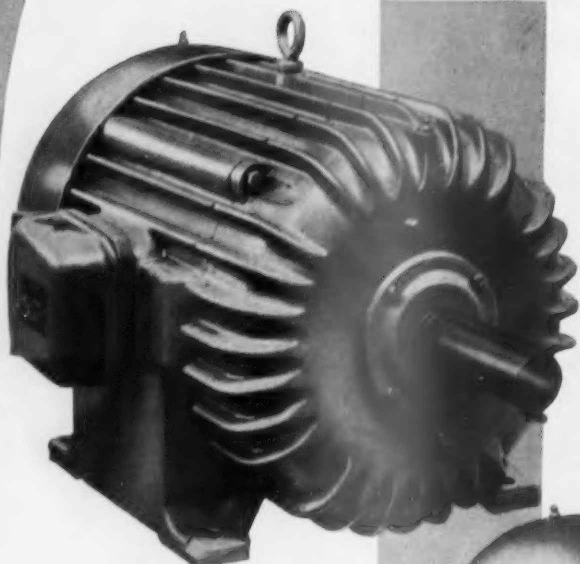
A BORG-WARNER PRODUCT

MORSE CHAIN DIVISION, BORG-WARNER LIMITED, LETCHWORTH. *Tel.:* LETCHWORTH 1833

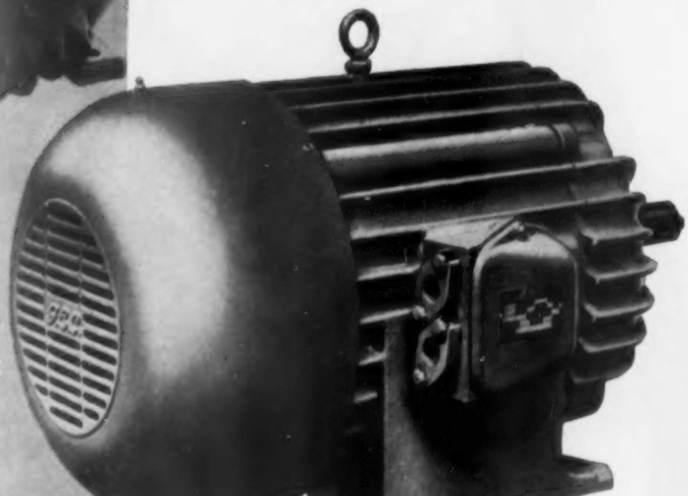
MANUFACTURERS OF AUTOMOTIVE TRANSMISSIONS AND MORSE CHAINS

B·W

Built to last!



G.E.C. MOTORS



STANDARDISED DIMENSIONS TO B.S. 2083 (1954)

- AVAILABLE FROM STOCK
- TOTALLY ENCLOSED FAN COOLED
- END WINDINGS TAPED TO GIVE INTER-PHASE INSULATION AND RIGIDITY
- SIX LEADS BROUGHT OUT TO TERMINAL BOX
- OUTPUT UP TO 25 h.p.
- DOUBLE IMPREGNATION
- FOR NORMAL DUTY IN ANY PART OF THE WORLD
- BACKED BY 50 YEARS EXPERIENCE

Ask for Technical Description No. 431

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

For all the best engines

BRICO
TRADE MARK

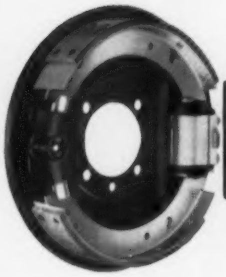
PISTONS
PISTON RINGS
CYLINDER LINERS
VALVE SEAT INSERTS
VALVE GUIDES
TAPPETS ETC.

QUALITY PAYS!

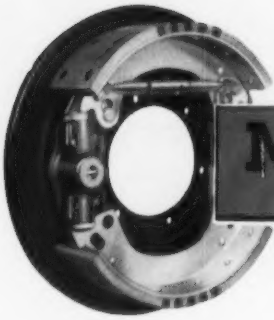
THE BRITISH PISTON RING CO. LTD., HOLBROOK LANE, COVENTRY

Cogent

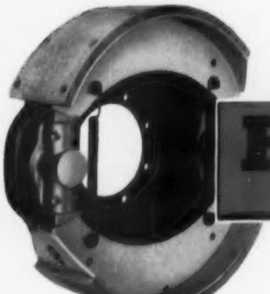

in the
long
run
the short cut is
"SPEEDICUT"
tools
FIRTH BROWN TOOLS LTD
SPEEDICUT WORKS, CARLISLE STREET EAST,
SHEFFIELD ENGLAND



LIGHT
duty



MEDIUM
duty



HEAVY
duty

For the baby car or the giant commercial transport vehicle, the Girling name means high efficiency brakes. Backed by unrivalled research and development facilities, Girling design and manufacture are geared to the production of equipment specifically designed for a specific job. For every type of motor vehicle, Girling Brakes are performing daily with the utmost reliability, always strengthening the proud claim . . .

GIRLING

THE BEST BRAKES IN THE WORLD

WAY OUT AHEAD

GIRLING LIMITED
KINGS ROAD
BIRMINGHAM 11

Sigma Multi-dimension Inspection Machines inspecting cranksha (39 dime

We will gladly send, to those with a genuine interest in measuring equipment, our new 48-page catalogue which describes and illustrates over 150 instruments.

ALFRED HERBERT LTD COVENTRY

The leading metrology specialists

OLYMPIA
JUNE 22 — JULY 6

WE SHALL BE DEMONSTRATING A COMPREHENSIVE RANGE OF INSTRUMENTS ON **STAND 311, (Grand Hall Gallery).**

MATRIX Inclinable Table with WATTS Microptic Circular Table.

Alfred Herbert Ltd. are distributors and specialists in the application of

SIGMA
HILGER and WATTS
COVENTRY GAUGE
TAYLOR - HOBSON
PITTER GAUGE and TOOL
AVERY
FELLOWS and other makes of *measuring and inspection equipment.*

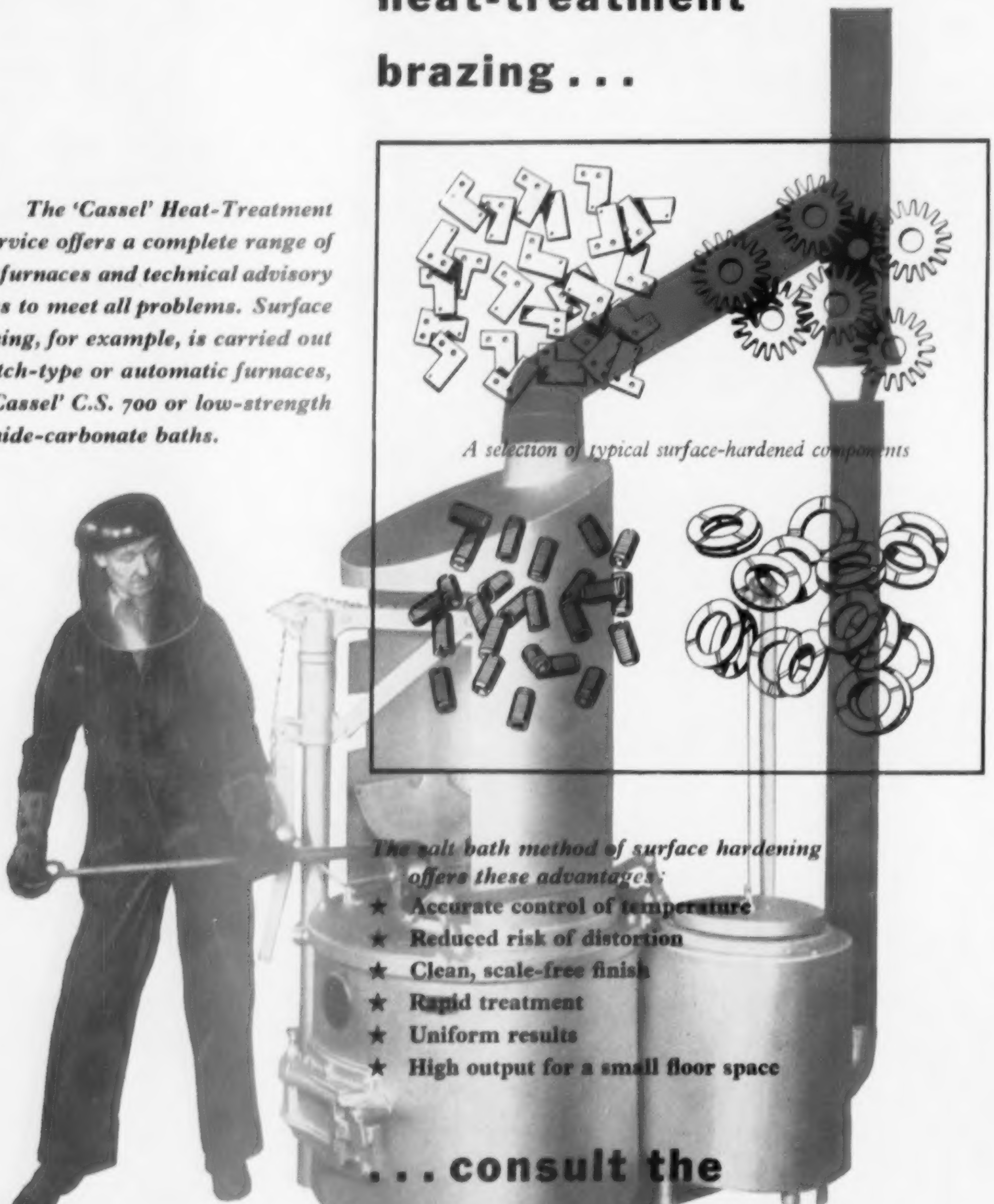
AVERY Electrodynamic
Balancing Machine

HILGER Universal Projector
AD2

MATRIX Turbine-blade
Edge Projector

for casehardening heat-treatment brazing . . .

The 'Cassel' Heat-Treatment Service offers a complete range of salts, furnaces and technical advisory facilities to meet all problems. Surface hardening, for example, is carried out in batch-type or automatic furnaces, using 'Cassel' C.S. 700 or low-strength cyanide-carbonate baths.



A selection of typical surface-hardened components

The salt bath method of surface hardening offers these advantages:

- ★ Accurate control of temperature
- ★ Reduced risk of distortion
- ★ Clean, scale-free finish
- ★ Rapid treatment
- ★ Uniform results
- ★ High output for a small floor space

. . . consult the 'Cassel' heat-treatment service

ICI

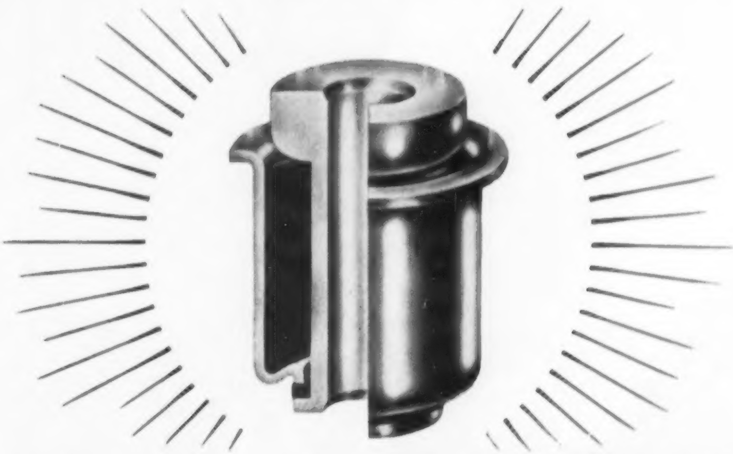
IMPERIAL CHEMICAL INDUSTRIES LTD.,
LONDON, S.W.1

CC.171

250,000

MILES

and as good as new



SILENTBLOC

ANTI-VIBRATION MOUNTINGS

● Bus bodies last longer when protected from vibration by Silentbloc flexible mountings. Of robust construction these units need no attention. Vibration is absorbed by a scientifically designed rubber insert which is protected from damage by a steel casing. Silentbloc mountings in use on double-deck buses were as good as new after 250,000 miles. Our Technical Department will be glad to submit mounting schemes.

SILENTBLOC LTD., MANOR ROYAL, CRAWLEY, SUSSEX. Tel.: CRAWLEY 2100

impact wrench

SIZE 24

Basically designed as a Nut Setting Tool, this Impact Wrench may be effectively used with the available attachments for screwdriving, tapping, drilling, grinding, wire-brushing or sanding.

Extra strong in design and construction this tool incorporates longer normal working life with minimum maintenance.

WRITE FOR LEAFLET I.W.202

R29

BALANCERS
DRILLS · GRINDERS · IMPACT WRENCHES

ROTARY SANDERS · RIGHT ANGLE NUT SETTERS
RIGHT ANGLE DRILLS

ARMSTRONG WHITWORTH
Power Tools

ARMSTRONG WHITWORTH & CO (Pneumatic Tools) LTD

Main Sales Office: **40 BROADWAY WESTMINSTER LONDON SWI**
Cable Address: ARMWHITOOL SOWEST LONDON *Phone:* WHItehall 5944
Works: **TYNEMOUTH ENGLAND** *Phone:* **NORTH SHIELDS 3111** *Grams:* **ARMWHITOOL TYNEMOUTH**

1603

She's just going to use another of those

HARPER CASTINGS

146 lb. base castings for operating theatre table

In hospitals, too, they rely on Harper Castings to be the perfectly finished utterly dependable mainstay of operating tables up and down the land.

Harper quality covers grey iron and Meehanite castings, also metal pressings, machining, enamelling and other finishes and sub-assembly work.

CASTINGS WITH THE HARPER SKIN

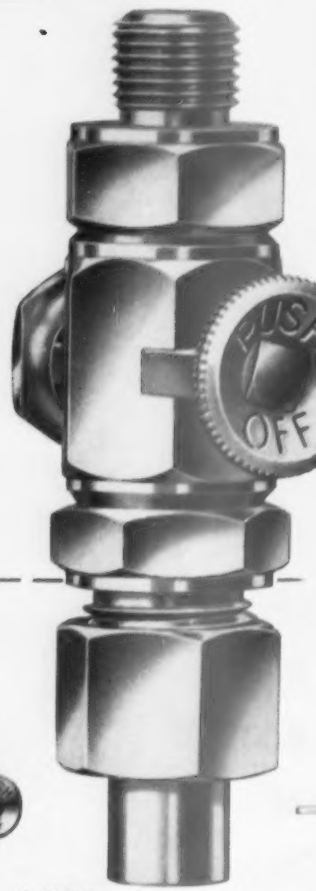
JOHN HARPER & CO. LTD.
JOHN HARPER (MEEHANITE) LTD.
ALBION WORKS · WILLENHALL · STAFFS

H539

Enots

CONCENTRIC CORK-SEATED TAPS

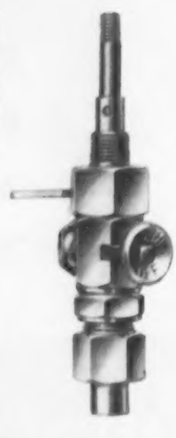
for Motor Cycles and Industrial Engines



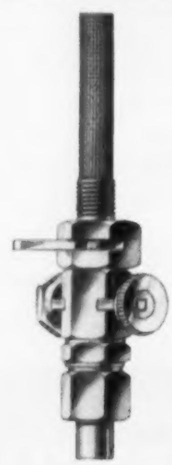
M 5157

A high standard of design, manufacture and finish ensures the first-rate efficiency of Enots Concentric Taps. Being cork-seated they are guaranteed 100% leak-proof, prices are moderate and deliveries are good.

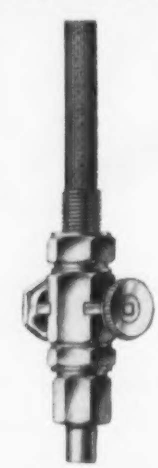
M 5157



M 9426



M 9428



M 5538

DETAILED INFORMATION OF THE FULL RANGE

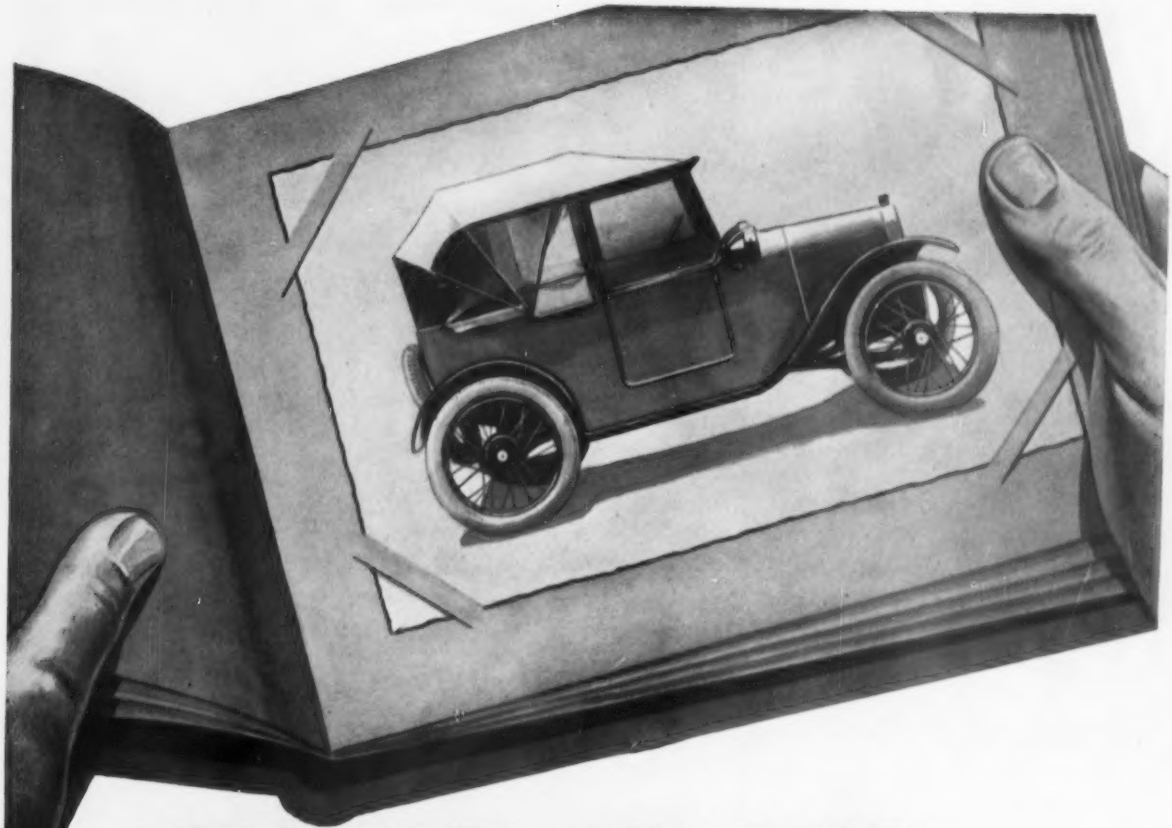
. . . can be found in our Leaflet of Concentric Taps and Filler Caps, No. CT 156 which will be gladly forwarded on request to :-

BENTON & STONE LTD.

ASTON BROOK STREET,
BIRMINGHAM, 6.

See our exhibits at the INTERNATIONAL MACHINE TOOL EXHIBITION, OLYMPIA 22nd June — 6th July on Stand 501, Empire Hall Gallery.

We are also exhibiting at the PRODUCTION EXHIBITION at OLYMPIA on the 23rd May to the 31st May on Stand 302, Grand Hall, Ground Floor.



TURN BACK THE PAGES...

One of the most famous cars in the world—the well-loved 'Baby' Austin of the nineteen twenties.

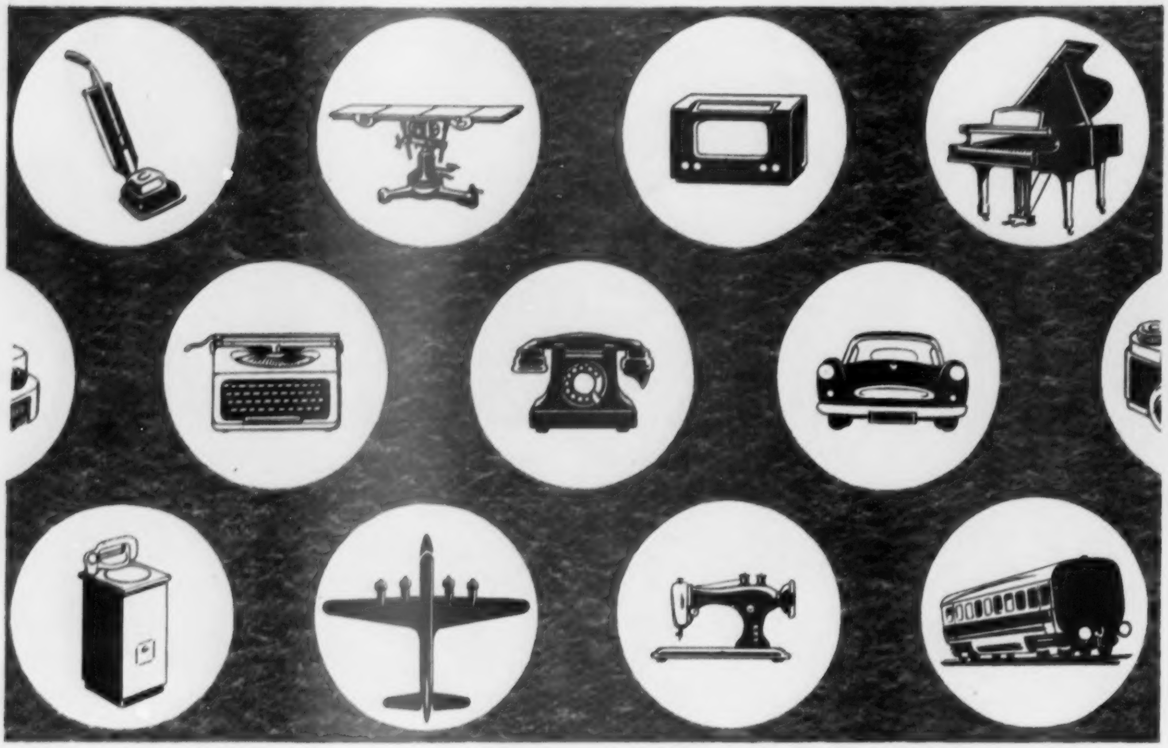
Hardy Spicer first supplied 'Hardy' flexible couplings for the Austin seven in 1922.

Today AUSTINS, in common with the majority of modern motor manufacturers, fit Hardy Spicer propeller shafts and couplings to its successor the present day A.30, and their entire range of passenger cars and commercial vehicles.

HARDY SPICER

HARDY SPICER LTD · BIRCH ROAD · WITTON · BIRMINGHAM 6

(A Birfield Company)



The Meadowfelt service is an integral part of the industrial picture

Service is the keystone of the Meadowfelt organisation. The result is that more and more industrial companies are specifying Meadowfelt for filters, seals, gaskets, washers, joints, shock-absorbent mounting—and the hundred-and-one other industrial applications of felt. Meadowfelt can be made to your precise specifications or you can leave it to us to produce felts that are right for the job. Meadowfelt can be made as hard as a board or as light as thistledown; it can be die-cut or punched; it is invaluable in packaging.

Meadowfelt is used in:

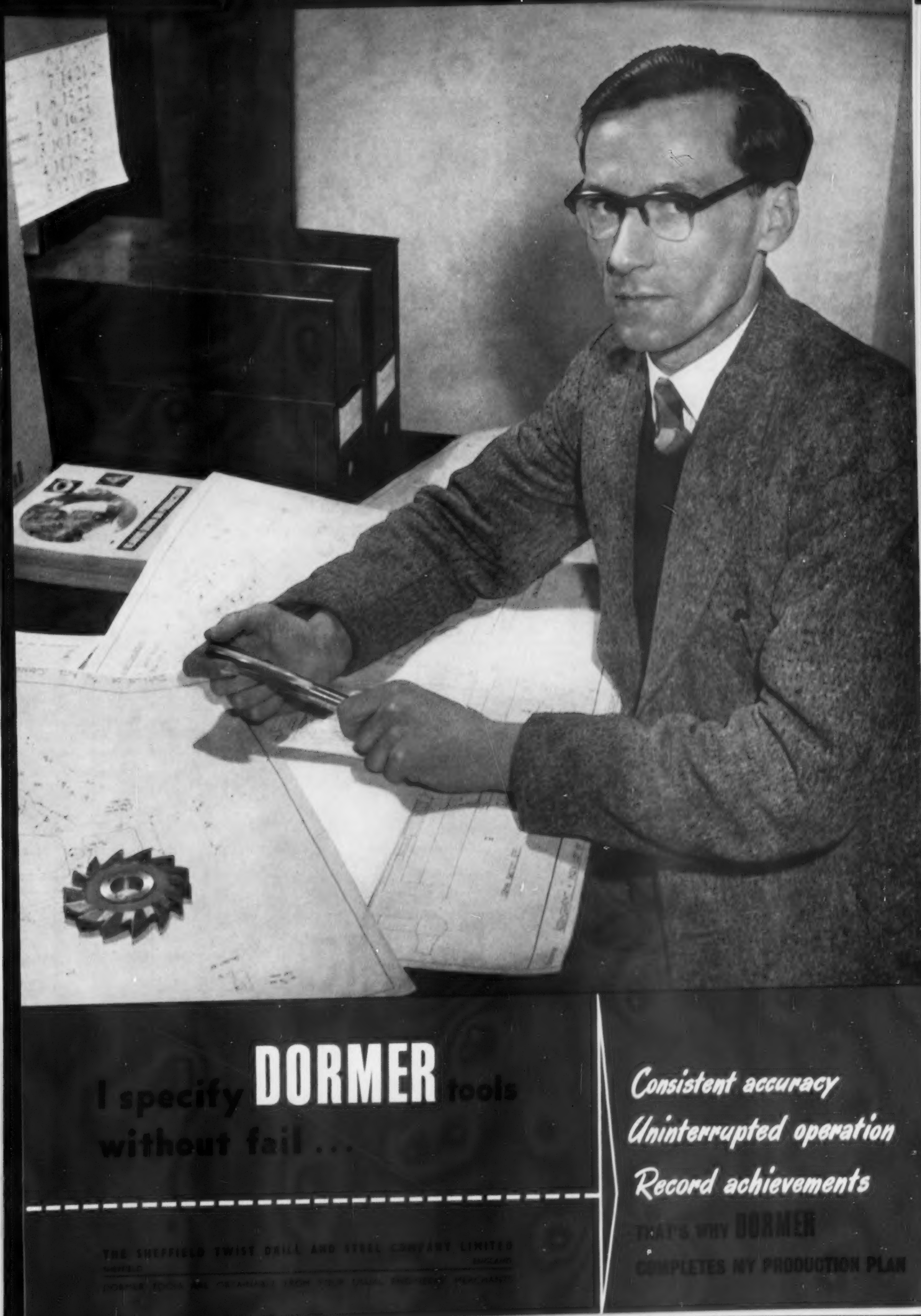
Aircraft
Motor cars
Surgical appliances
Heavy engineering
Electrical appliances
Typewriters
Telephones
Sewing machines
Cameras
Radios

and in all kinds of industrial products large and small

Meadowfelt

Tested and Trusted by Industry

THE LONG MEADOW FELT COMPANY, KIDDERMINSTER—THE FELT DIVISION OF CARPET TRADES LIMITED


I specify DORMER tools without fail ...
Consistent accuracy
Uninterrupted operation
Record achievements
THAT'S WHY DORMER
COMPLETES MY PRODUCTION PLAN
THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED

assembly lubricants that "stay put"

On motor-car engines—and other mechanical equipment—oil films tend to run from bearing surfaces during the period of immobility between assembly and running-in. A **'dag'** dispersion of colloidal graphite applied initially provides all the bearing surfaces with the protection of a graphite film which will "stay put" during the critical starting up and running in stages

Illustration shows ***'dag'*** *colloidal graphite being applied during engine-assembly at the Works of the Standard Motor Co. Ltd., Coventry.*

ACHESON COLLOIDS LTD

18 Pall Mall, London, S.W.1 *Tel: Whitehall 2034-9 · Grams: Oildag, Piccy, London*

Wickman

2 new
CARBIDE MILLING CUTTERS
√ Right for performance
√ Right for price

WICKMAN
HI-TEN
FOR STEELS
£25-10-0
8 in. DIA. 8 BLADES

WICKMAN
FERROMILL
FOR CAST IRONS
AND NON-FERROUS METALS
£38-0-0
8 in. DIA. 20 BLADES

- ★ *Inserted blades in heavy forged steel bodies.*
- ★ *Readily available replacement blades at low prices.*
- ★ *Guaranteed by Britain's largest producers of carbide tools.*
- ★ *Screw releasing wedge clamping, simplifying blade renewal.*
- ★ *Tipped with Britain's longest lasting carbide — Wimet.*

STANDARD CUTTER LIST

HI-TEN FOR STEELS

Dia.	Number of Blades	Price Cutter Complete			Price Blades Each		
		£	s.	d.	£	s.	d.
6″	6	18	5	0	1	8	6
8″	8	25	10	0	1	8	6
10″	10	34	0	0	1	8	6

Standard Spindle Nose Fitting

Prices ex Coventry Works

FERROMILL FOR CAST IRON AND NON-FERROUS METALS

Dia.	Number of Blades	Price Cutter Complete			Price Blades Each	
		£	s.	d.	s.	d.
4″	8	15	5	0	18	6
6″	14	26	10	0	18	6
8″	20	38	0	0	18	6
10″	26	51	0	0	18	6
12″	32	63	0	0	18	6

Standard Spindle Nose Fitting

PRICES FOR NON-STANDARD SIZES QUOTED ON REQUEST.

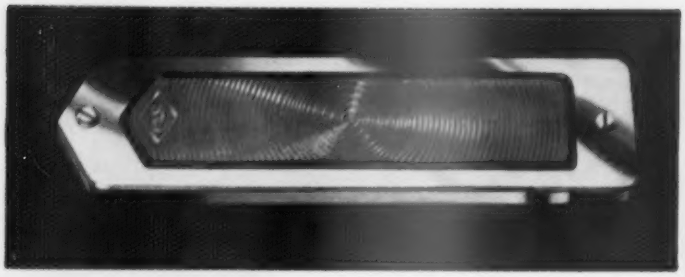
★ ***Many Standard Cutters Available from Stock***

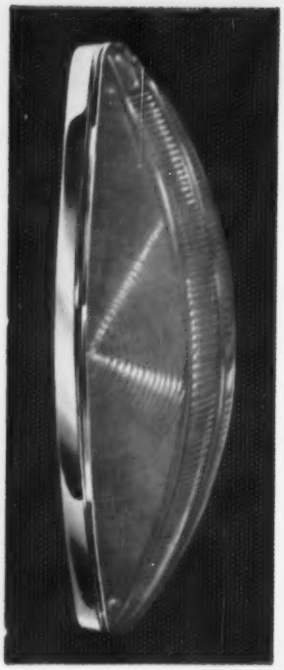
Others available on quick delivery

WICKMAN LIMITED

WIMET DIVISION, TORRINGTON AVENUE, COVENTRY

Telephone: Tile Hill 66621

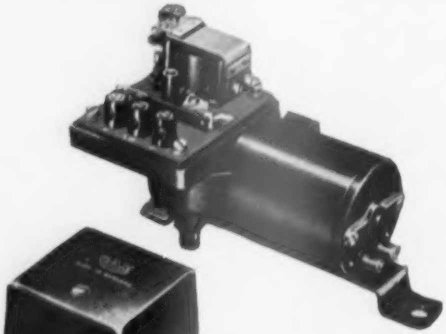




TURN to FLASHERS

C.A.V. Flasher Indicator Equipment is designed especially for use on public service and transport vehicles, and is robust in construction to ensure trouble-free operation. The optical design of the lamp units is carefully planned to give maximum visibility and attention value. The motor driven flasher unit is positive in action and gives 80/90 flashes per minute. Three types of lamp are available: Circular for front or rear mounting; side mounting type, a most popular fitting; and arrow type for rear mounting (and front also if required). All are single purpose lamps, giving unmistakable signals, even in bright sunlight. Self-cancelling switch (illustrated) with adjustable time delay, or simple hand cancelling type as required.

FLASHER INDICATOR EQUIPMENT



Motor driven flasher unit with cover removed.

Self-cancelling switch with warning light.

C.A.V.

The World's Leading Manufacturers of

FUEL INJECTION and ELECTRICAL EQUIPMENT

C.A.V. LIMITED, ACTON, LONDON, W.3.

AP174 807

The Steel Company of Wales Limited

THE MOST IMPORTANT MANUFACTURER OF
MILD STEEL FLAT ROLLED PRODUCTS IN EUROPE

STEEL SHEETS and COILS *up to 72" wide*

PLATES *up to ·75" thick*

TINPLATE *Hot-dipped and Electrolytic*

Details of the new selling arrangements effective from 31st March, 1956, have already been sent to all our Home Trade customers.

Further information is available on request, from

THE SALES CONTROLLER, THE STEEL COMPANY OF WALES LTD.
CHESHAM HOUSE, REGENT STREET, LONDON, W.1

TELEPHONE: REGENT 7941 (10 LINES)

No "teething troubles" here

This immense battery of precision machinery ensures a complete lack of teething troubles and gives to the rear axle that dependability and sturdiness that is so essential for present day needs.

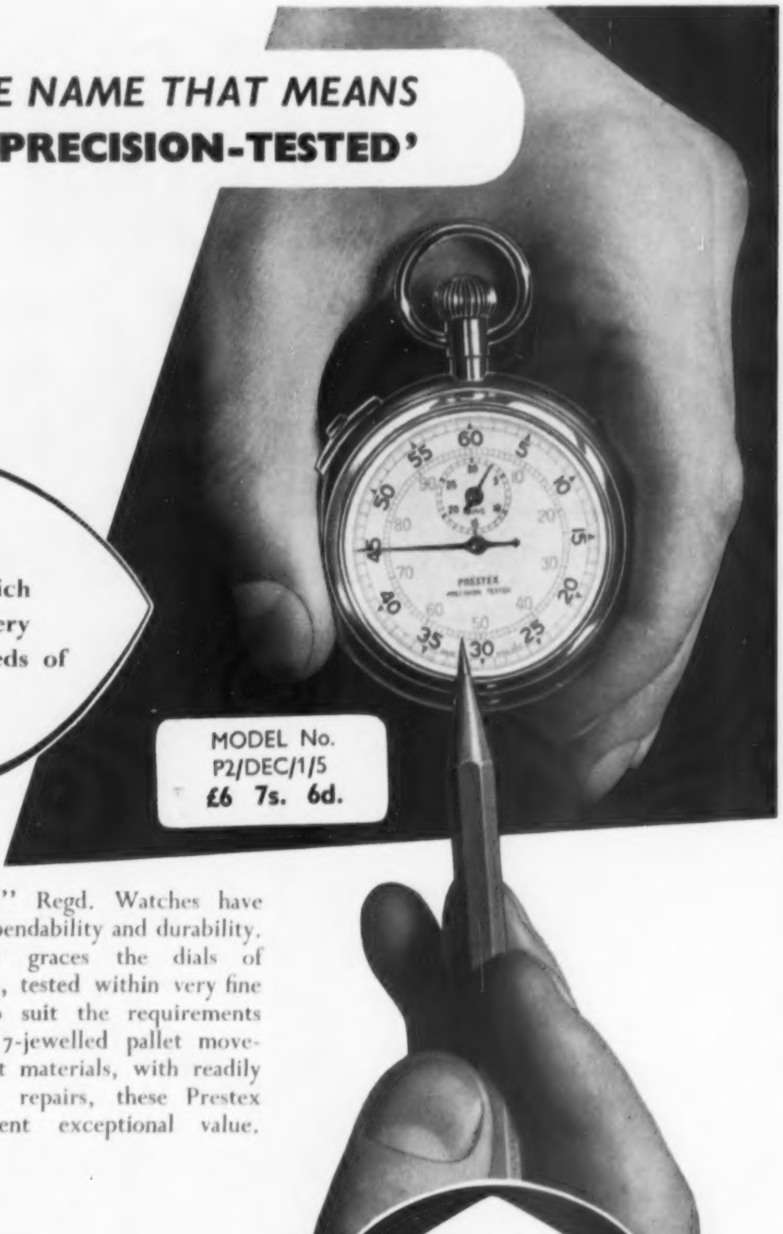
THE MOSS GEAR CO. LTD · CROWN WORKS · TYBURN · BIRMINGHAM 24

Phone: ERDington 1661-6

Grams: 'Mosgear, Birmingham'

MOSS GEARS

*INTRODUCING THE NAME THAT MEANS BRITAIN'S BEST—***'PRECISION-TESTED'**



★ **This is the STOP-WATCH which fulfils the very exacting needs of science and Industry.**

MODEL No.
P2/DEC/1/5
£6 7s. 6d.

In the industrial north "Prestex" Regd. Watches have long been known for accuracy, dependability and durability. Now this time-honoured name graces the dials of PRECISION-TESTED Stop-watches, tested within very fine accuracy-limits, specially made to suit the requirements of Science and Industry. With 7-jewelled pallet movement, and made from the finest materials, with readily interchangeable parts for speedy repairs, these Prestex Precision-Tested watches represent exceptional value. Compare the price.

● **PRESTEX Precision-Tested Stop-Watches are available only from Prestons, Ltd.,**

Prestons LIMITED
BRITAINS LARGEST SUPPLIERS OF STOP-WATCHES TO INDUSTRY

PRESTEX
Precision-Tested
STOP-WATCH

Send for illustrated literature to . . .

PRESTONS, LIMITED,
'PRESTEX' STOP-WATCH DIVISION
BOLTON——LANCS.
TELEPHONE: BOLTON 876/7

RAC — OBSERVED FUEL CONSUMPTION TESTS AT SILVERSTONE

17% FUEL SAVING ON THE HUMBER HAWK fitted with the Laycock Overdrive

COMPARISONS IN M.P.G.

	Without Overdrive	With Overdrive
TRIUMPH TR3 (1991 c.c.)	32·86	37·46
VANGUARD III (2088 c.c.)	30·21	34·69
HUMBER HAWK (2267 c.c.)	22·84	27·54
ROVER "90" (2638 c.c.)	26·01	31·22
JENSEN "541" (3993 c.c.)	22·43	29·04

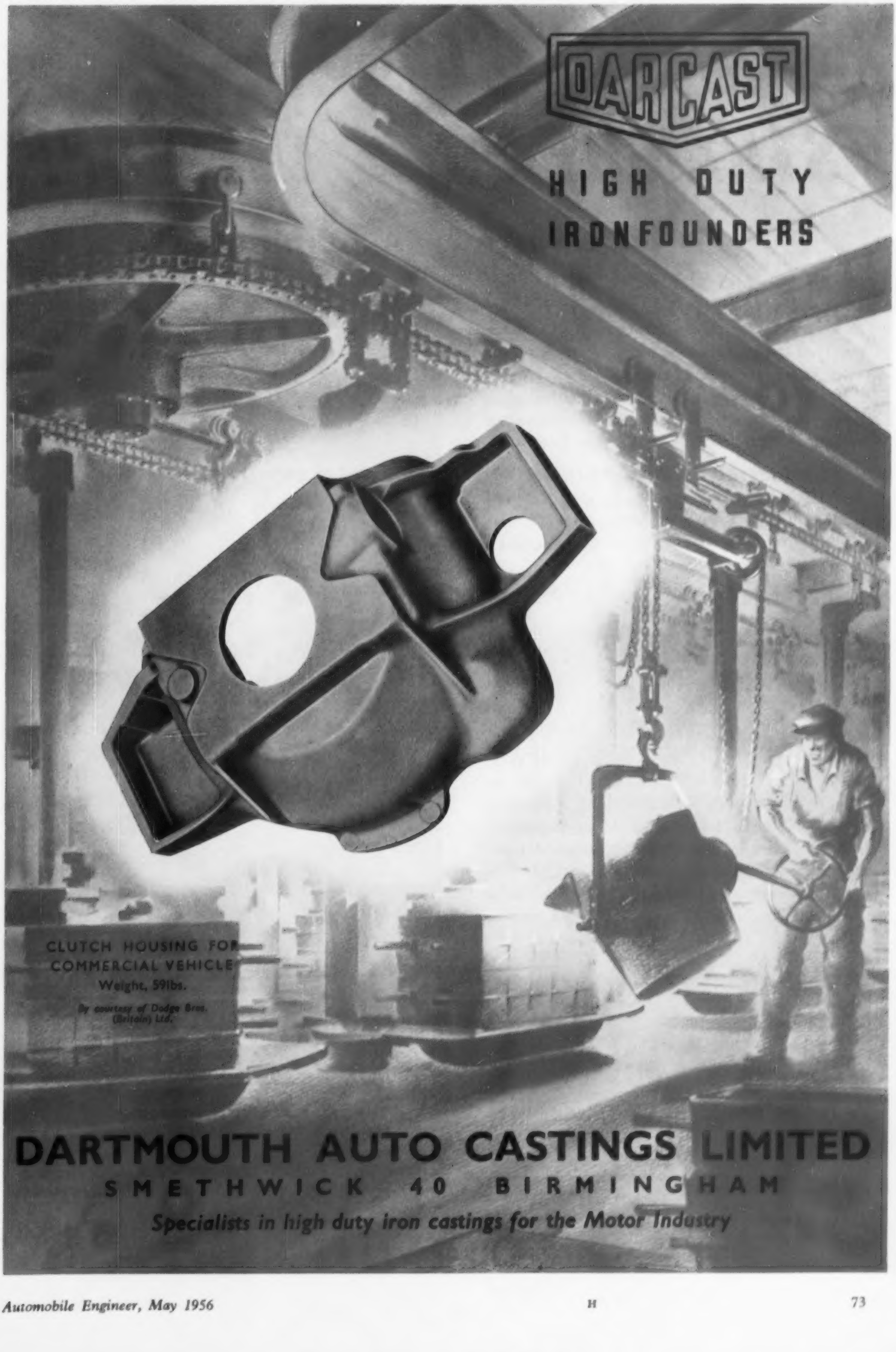
Taking an average for the five cars tested with the overdrive unit in operation the reduction in fuel consumption was approximately **16%**

Among the many cars R.A.C. tested at Silverstone recently, the Humber Hawk gave impressive proof of the petrol-saving advantages of the Laycock de Normanville overdrive. The test run with overdrive "IN" showed a 17% decrease in consumption compared with an overdrive "OUT" run. The Laycock Overdrive also offers *exclusive* advantages of . . . complete driver control; fully power-sustained changes, and positive engine-braking under all conditions.

LAYCOCK ENGINEERING LIMITED — SHEFFIELD

Enquiries to: Laycock Engineering Limited, Overdrive and Transmission Sales Division, Westminster Bank Chambers, 16/17, Hertford Street, Coventry.

Under exclusive licence from Auto Transmissions Ltd., Coventry. Electrical controls by Joseph Lucas (Electrical) Ltd.


DARCAST
HIGH DUTY
IRONFOUNDERS
CLUTCH HOUSING FOR
COMMERCIAL VEHICLE
Weight, 59lbs.
By courtesy of Dodge Bros. (Britain) Ltd.
DARTMOUTH AUTO CASTINGS LIMITED
SMETHWICK 40 BIRMINGHAM
Specialists in high duty iron castings for the Motor Industry

Now... *HIGH GLOSS STRAIGHT FROM THE GUN!*

'Drive-away' dry in 30 minutes !

Now—whether there's drying equipment available or not—you can take on rush spray jobs with Berger Viton half-hour Synthetic Enamels.

Straight from the gun, they give a lasting, high gloss finish—gleaming bright without a 'rub'—and the vehicle can be driven away in half an hour if necessary.

SIMPLIFIED MIXING SCHEME

As well as an extensive range of manufacturers' standard colours, there is the VITON MIXING SCHEME which will enable you to produce an approximate match immediately and economically.

This scheme consists of only 14 basic colours plus black and white; a mixing formulæ book and a simple measuring stick are available FREE. The formulæ cover the standard colours of the leading car manufacturers. The skilled operator can also match colours not covered by the formulæ.

THAT 'SHOWROOM' FINISH

Viton isn't only for rush jobs. You can bring a Viton finish up to a glittering 'showroom' perfection by a quick burnish with Viton Smoothing Compound, and a final polish with "Lifeguard" liquid polish.

For all Refinishers, Viton is the way to new business, to extra profit—at the lowest possible cost.

Why don't *you* start using it right away? It is easily available through your local factor. Phone him about supplies today.

VITON

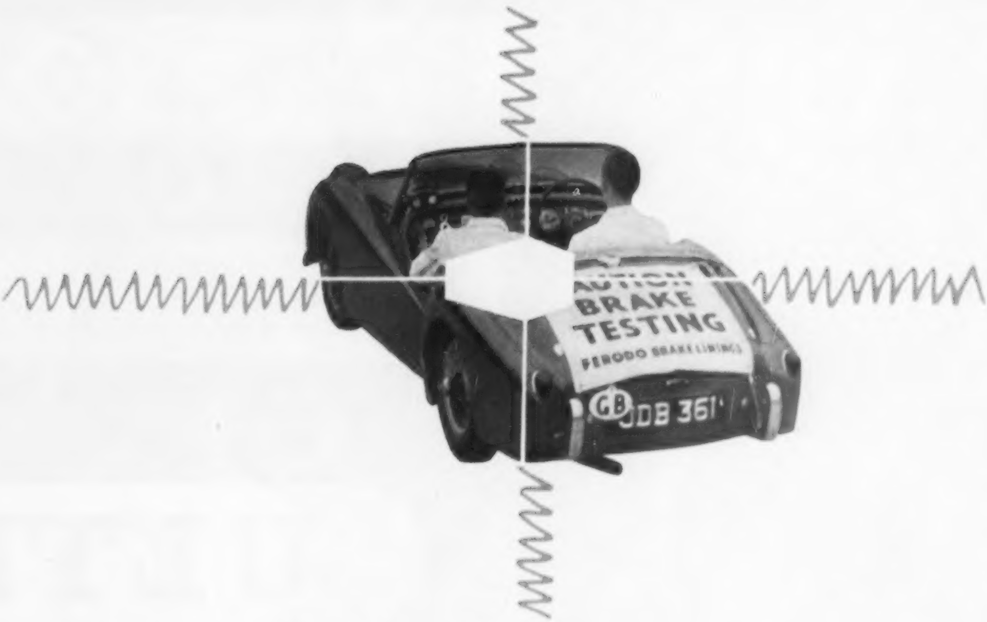
Half-hour Synthetic Enamels

PROXCELIN

FOR BETTER THAN NEW FINISHES!

If a *concours d'elegance* winning standard is required, respray with Proxcelin cellulose enamel. There is a Proxcelin Mixing Scheme, too. Your factor has supplies.

MADE BY LEWIS BERGER (GT. BRITAIN) LTD., MORNING LANE, HOMERTON, LONDON, E.9. TELEPHONE: AMH 3321



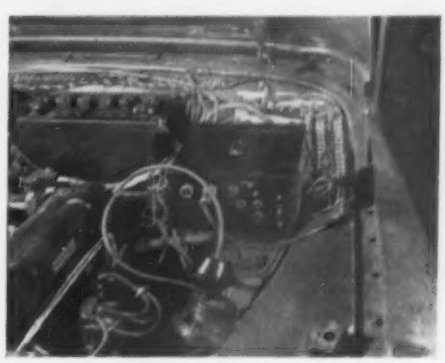
The car with a Built-in brain

This car of the Ferodo Test Fleet is packed with equipment to record and analyze brake performance. For, when arranging schedules for tests, Ferodo research workers must know what a brake lining is expected to do under practical conditions, and that is what these instruments tell them.

There is a high-speed multi-pen recorder which notes four parameters of brake performance: speed, deceleration, brake drum temperature and rate at which work is done at the brakes.

This information is collected electronically, and used by Ferodo to devise accurate, reliable testing schedules that help to produce brake linings highly resistant to fade and wear.

The electronic calculating unit installed in the boot of the TR.2.



The power pack for the electronic apparatus, on the right of which may be seen some of the intricate cable connections.

FERODO

***ANTI-FADE* Brake Linings**

FERODO LIMITED · CHAPEL-EN-LE-FRITH *A Member of the Turner & Newall Organisation*

Who is it that

performs an

ULTRA

DUTY*

to Britain's

motor industry?

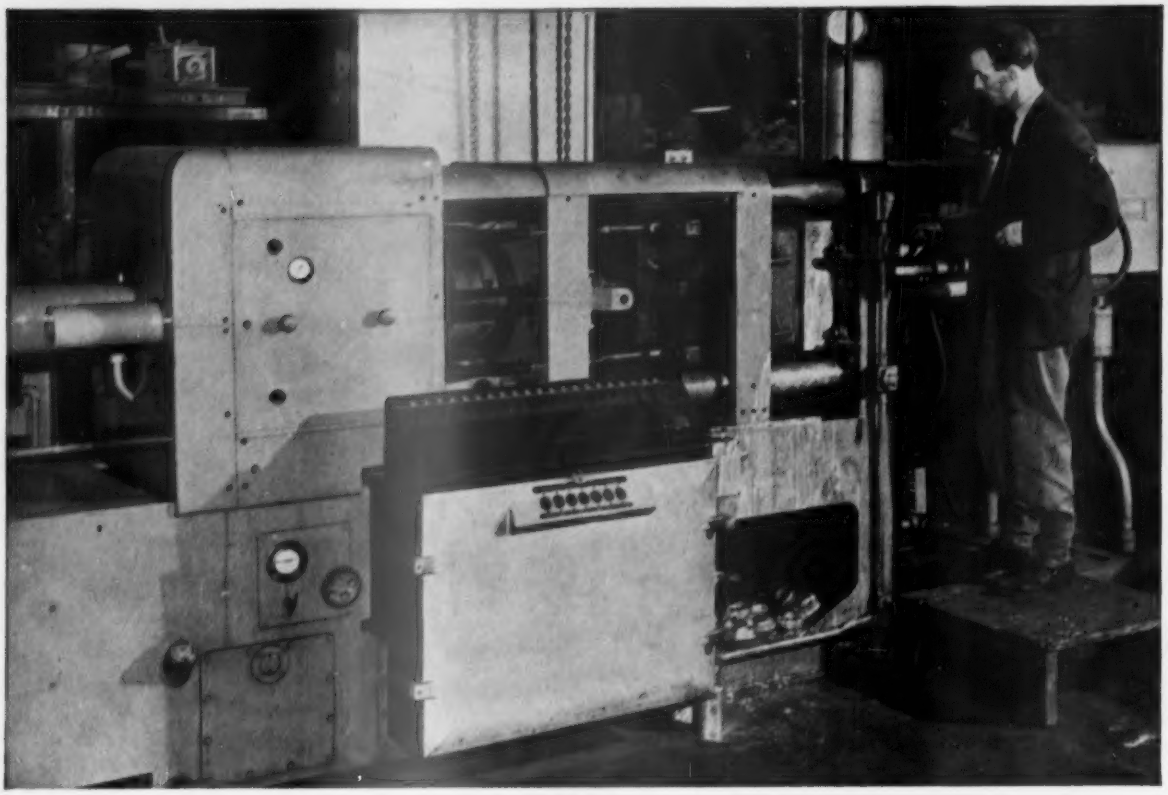
THAT FIRM AT LEICESTER

OF COURSE!

*

THAT'S

ME!



REDUCE YOUR MACHINING WITH

PRESSURE DIE CASTINGS

Castings to very fine limits can be supplied in quantity to any specification of Zinc and Aluminium Alloy.

Considerable savings in machining costs can be effected where pressure die castings of a suitable design are required in large quantities. We are fully equipped to design and manufacture dies and produce castings for quantity supply at competitive prices.

West Yorkshire Foundries Ltd.

SAYNER LANE, LEEDS 10
Telephone: Leeds 29466

London Office:
HANOVER HOUSE, HANOVER SQ., W.1
Telephone: MAYfair 8561

1881 · 1956
75
YEARS OF SMALL & PARKES PROGRESS

*** brake squeal:**

Audible evidence of vibrations set up in the brake assembly—primarily attributable to "stick slip" characteristics at the interface of the brake liner and brake drum—a factor which has to be considered in the formulation of every DON *brake liner.*

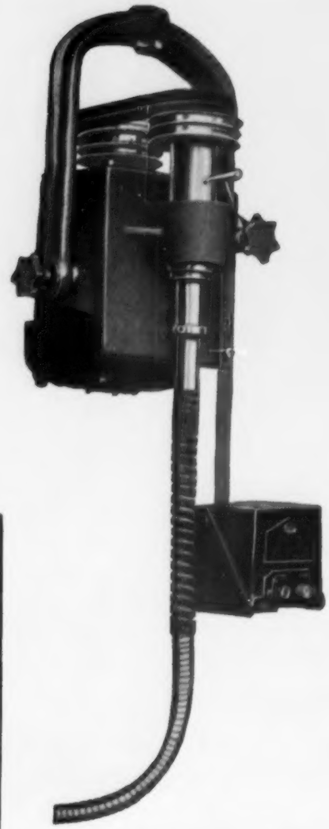
A Nation-wide chain of Depots to serve you:

BELFAST *28967*
BIRMINGHAM 5 *Midland 4659*
BLACKBURN *6581*
BRISTOL *27214*
CARDIFF *27026*
CARLISLE *21589*
CHESTER *21280*
COVENTRY *64914*
DUNDEE *1728*
EDINBURGH 1 *Central 4234*
GLASGOW C2 *Central 4595*
HARROGATE *67058*
HULL *Central 52072*
IPSWICH *3023*
LEEDS 3 *20664/5*
LEYTON *Leytonstone 6068*
LIVERPOOL *Royal 5202 and 1251*
MANCHESTER 3 *Blackfriars 0596*
NEWCASTLE-ON-TYNE 2 *27142 and 27942*
NOTTINGHAM *43646*
SHEFFIELD 1 *25529*
SOUTHAMPTON *21276*
STOKE-ON-TRENT *44021*
WAKEFIELD *4571*
WIMBLEDON *4248/9*
Republic of Ireland:
DUBLIN, 35 Westland Row *66597 and 66518*

this is the liner that said goodbye to *brake squeal

It's Don of course
BRAKE LINERS
woven or molded

SMALL & PARKES LIMITED HENDHAM VALE WORKS MANCHESTER 9 *London: 76 Victoria Street, SW1*



Morrisflex

THE WORLD'S FINEST FLEXIBLE SHAFT EQUIPMENT

Manufactured by

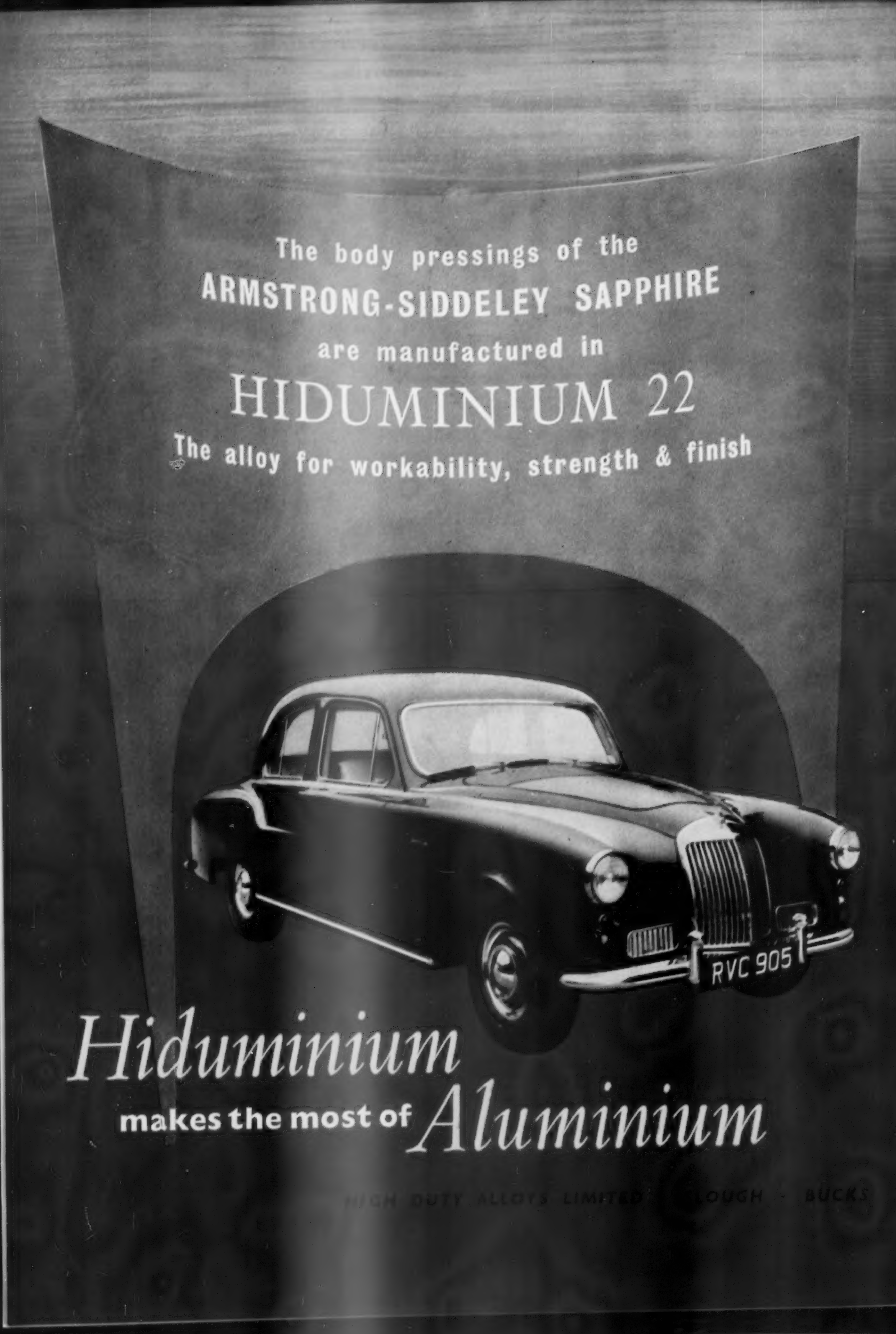
B. O. MORRIS LTD., MORRISFLEX WORKS, BRITON ROAD, COVENTRY. Tel. Coventry 5081 Grams 'Morisflex' Cov.

RTB

FIRST
IN EUROPE
TO MODERNIZE
PRODUCTION OF
STEEL SHEETS
AND TINPLATE

RICHARD THOMAS
& BALDWINS LTD

47
PARK STREET
LONDON
W.1



The body pressings of the
ARMSTRONG-SIDDELEY SAPPHIRE
are manufactured in
HIDUMINIUM 22
The alloy for workability, strength & finish
RVC 905
Hiduminium
makes the most of Aluminium
HIGH DUTY ALLOYS LIMITED
BUCKS

Improved Oil Sealing

Specify Weston Oil Seals and 'O' rings at the blue print stage

And for all types of replacements

WESTON
OIL SEALS

CHARLES WESTON & CO. LTD.

Irwell Bank Works Douglas Green Pendleton Salford 6.

Telephone: Pendleton 2857-8-9; Birmingham: Midland 6952; London: Holborn 0414

...Who serve you well!

W

Lloyds Ductile Iron

has a greater tensile strength than some steels with the castability and machineability of iron

GRADE	Ultimate Tensile Stress Tons/sq. in.	Yield Stress Tons/sq. in.	Elongation % (on 2 in.)	Transverse Rupture Stress Tons/sq. in.	Compression Strength Tons/sq. in.	Impact Izod. 10 mm. sq. notched ft. lb.	Brinell Hardness
PEARLITIC — —	35–45	25–35	1–5	55–65	65–80	4	230/280
PEARLITIC/FERRITIC	32 min.	24 min.	5 min.				
FERRITIC — —	27/35	20/25	10/25	55/60	48/58	12	140/180

CYLINDER BODY in Ductile Iron. Weight 30 lbs.

TRANSMISSION BEARING in Ductile Iron. Weight 50 lbs.

With Lloyds Ductile Iron, the graphite flakes common to ordinary cast iron are present in the form of spheroids. It can be cast as accurately and as easily as ordinary cast iron, but compared with flake-graphite iron is stronger, tougher and ductile.

Lloyds Ductile Iron is now being used for a wide range of engineering parts and in some instances is replacing cast or forged steels, malleable iron and non-ferrous metals. It also replaces grey iron, permitting reduced section thickness to take advantage of the better properties offered and it may well enable you to re-design your present castings for more efficiency.

The successful casting of Ductile Iron demands the strictest and most experienced metallurgical and melting control, but Lloyds have been casting it daily, continuously since 1950! Technical advice freely given on request.

Lloyds of Burton

Ductile Iron is only one of the range of High Duty Irons cast by Lloyds

LLOYDS (BURTON) LTD., WELLINGTON WORKS BURTON-ON-TRENT · TELEPHONE: BURTON 3867

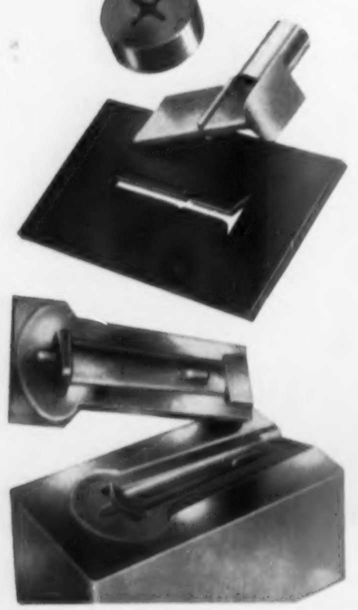
HEENAN-DYNAMATIC DYNAMOMETERS

are in widespread use for testing all kinds of prime movers. They operate upon the Eddy-Current principle and with the electronic control normally employed, very desirable torque-speed characteristics are provided.

H&F

HEENAN & FROUDE LTD · WORCESTER · ENGLAND

the FIRST practical applications of SPARK EROSION machining—



included SPARCATRON

Now, over three-hundred SPARCATRON applications are operating throughout the world

Earliest applications of spark erosion machining included SPARCATRON machines which provide a long sought means for "cutting" intricate shapes, profiles, forms or impressions accurately and at relatively high speeds in hard and tough materials and where hitherto machining was either uneconomical or impracticable. Their superiority whereby up to four spark-heads can be operated from one control cabinet shows savings in equipment and floor space. SPARCATRON set a high standard and constant development ensures that SPARCATRON maintains the lead in the field of spark erosion.

SPARCATRON spark erosion machining was pioneered and is established in the toolmaking industries for press tools and dies, in cemented carbides and hardened steels. There are many applications in the making, reconditioning or alteration of dies and moulds for diecasting, drop forging, hot-brass stamping, plastics, rubber and ceramics, and in the manufacture of wire drawing and extrusion dies.

Manufactured by Impregnated Diamond Products Ltd.

SOLE SELLING AGENTS GT. BRITAIN & N. IRELAND

BURTON GRIFFITHS & CO. LTD., KITTS GREEN, BIRMINGHAM

4 Telephone: STECHFORD 3071

BURTON GRIFFITHS

AUTOMOBILE ENGINEER

CONTENTS

165 Editorial *Free-piston Engines*

166 Jaguar 2·4 Litre Engine *A high-performance unit designed to give scope for further development*

179 Dual Purpose Clutch *A unit comprising two clutches in tandem, one for the main drive and the other for the power take-off*

181 Whiteley Power-Assisted Steering *A development with the valves incorporated in the piston of the jack*

183 Pneumatic Gauging *Diverse applications of the Mercer dial-indicating, back-pressure type instrument*

191 Investigation of Cutting Tool Life *The use of radio-active tracer elements to determine factors that affect the rate of wear of cutting tools*

194 Spot-Welded Wheels *Sciaky automatic, three-phase, resistance welding machines*

201 V-8 Engines *A review of current engine design in the United States of America*

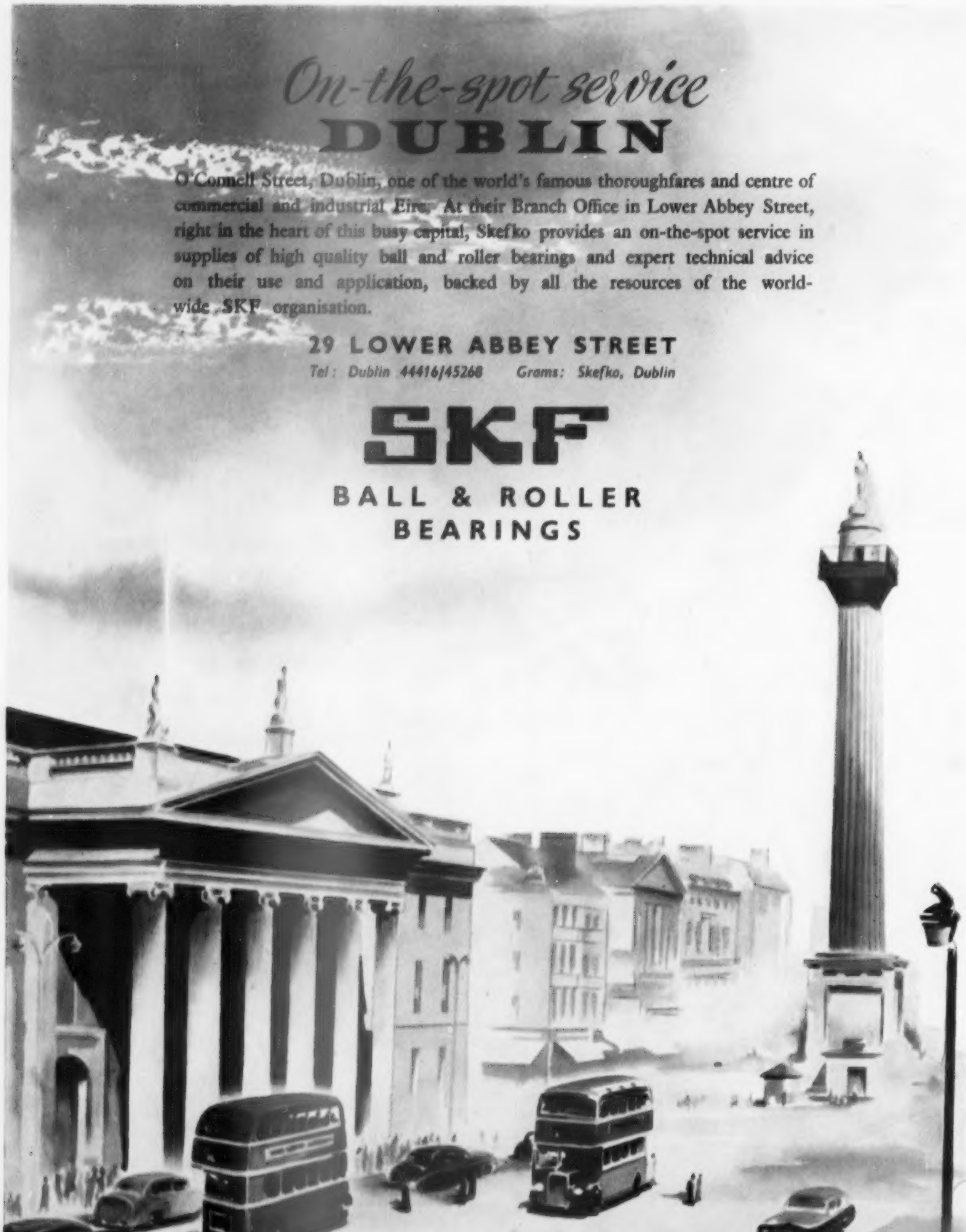
206 Automobile Brakes J. W. Kinchin *Considerations affecting fade and stability*

THIN-WALLED OR FRAGILE COMPONENTS AND SUPER-FINISHED WORK CAN BE PRECISELY CHECKED BY MEANS OF A MERCER FIXED-GAP, DIRECT-JET, AIR GAUGE, WITHOUT RISK OF DISTORTION, DAMAGE, OR DEFACEMENT

Published the second Wednesday in every month
by ILIFFE & SONS LIMITED
Dorset House, Stamford Street, London, S.E.1.
Telephone · Waterloo 3333 *(60 lines)*
Telegrams · Sliderule, Sedist London.
The annual subscription inland and overseas is £2 17s. 0d. including the special number
Canada and U.S.A. $8·50

BRANCH OFFICES
Coventry · 8-10 Corporation St.
Telephone · Coventry 5210
Birmingham 2 · King Edward House, New St.
Telephone · Midland 7191-7
Manchester 3 · 260 Deansgate
Telephone · Blackfriars 4412
Glasgow, C.2 · 26B Renfield St.
Telephone · Central 1265-6

VOLUME 46 NUMBER 5 MAY 1956



One of a series of advertisements featuring the main towns where SKF service is centred. Other SKF offices are at :—ABERDEEN · BELFAST · BIRMINGHAM · BRISTOL · CARDIFF · EDINBURGH · EXETER · GLASGOW · LEEDS · LEICESTER · LIVERPOOL · LONDON · LUTON · MANCHESTER · NEWCASTLE UPON TYNE · NOTTINGHAM · SHEFFIELD · SOUTHAMPTON

G134

Editor *J. B. Duncan*
Editorial Staff *T. K. Garrett, A.M.I.Mech.E. A.F.R.Ae.S.(Associate Editor)*
F. C. Sheffield

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Free-Piston Engines

HITHERTO, little consideration has been given to the free-piston engine as the power unit for road vehicles, and developments have in the main been confined to large stationary installations and, more recently to ship propulsion. More recently still, Renault have built a locomotive with a free-piston unit which has done considerable successful service. They have also developed an experimental unit for road vehicle propulsion. In the United States of America too, developments are under way and on May 15th General Motors will introduce an experimental private car, the XP-500, with a free-piston engine.

In this country much development work has been carried out on the Pescara-type unit by Alan Muntz and Co. Ltd., and a short time ago they granted a licence to Associated British Engineering Ltd. for manufacturing Pescara-type free-piston engines. It is significant that the licence includes gasifiers with diesel pistons of less than 6in diameter. This suggests increasing interest in this type of engine for road vehicle work.

The free-piston engine is essentially an opposed-piston, two-stroke engine with large diameter air-compressor pistons arranged in tandem with the engine pistons. There are no connecting rods and no crankshaft. All the air compressed is used to scavenge and supercharge the engine cylinder to something in the order of 45 lb/in^2. The combustion products and the excess scavenge air are fed to a gas turbine which furnishes the useful power. Therefore, the complete power unit includes both reciprocating and rotary units. Generally, the integration of basically different principles results in a compromise, which, even if it is of a practical nature, is of lowered efficiency. However, as Dr. H. R. Ricardo states in reference to the compounding of the diesel engine with the gas turbine: "The piston engine is eminently suitable to deal with relatively small volumes at high pressure and temperature, and the turbine, by virtue of its high mechanical efficiency and large flow areas, to deal with large volumes at low pressures. Clearly the logical development is to combine the two in series to form a compound unit".

The free piston engine gasifier operates with compression pressures in the order of 1,000 lb/in^2 in the engine cylinder. This is the basic reason for its relatively high thermal efficiency of 40 to 45 per cent. Compounded with a gas turbine, the overall thermal efficiency is about 35 per cent, and a satisfactory rate of fuel consumption is attained.

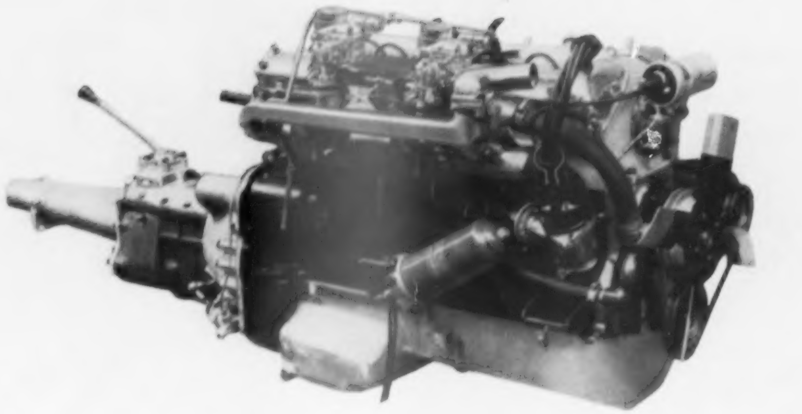
For road vehicles, the free-piston gasifier-turbine unit has attractive features. It is, of course, more suitable for large public service and commercial vehicles than for small private cars on the counts of first cost and complication. Such a power unit, because of its robustness, could prove especially useful for military vehicles.

At present, the gas turbine is generally looked upon as the development that may eventually oust the conventional piston-type engine, but, as is well appreciated, serious problems wait to be solved before the gas turbine can be commercially suitable for use in road vehicles. Apart from the manufacturing difficulties as regards both materials and methods, the specific rate of fuel consumption is inordinately high by piston engine standards. This can, of course, be countered by a system of heat recovery, but an adequate heat exchanger for a road vehicle has yet to be evolved. The recuperative type with transfer of heat through thin wall tubes is too bulky and vulnerable; the regenerative type in which heat is transferred in a moving matrix of refractory material has so far been impracticable as regards sealing.

There are not the same disadvantages with a free piston gasifier-turbine plant. Individually mounted and ducted together, the gasifier and turbine are easy to install. Furthermore, as the turbine operates at relatively low temperatures in comparison with those of a gas turbine, about 900 deg F, it can be of simple construction and of materials that are much less expensive and much more easily worked. The exhaust is relatively cool and there is no need for an expensive and bulky heat exchanger. The gasifier can be produced on simple machining equipment, and will use standard diesel fuel injection equipment.

As the turbine is purely rotary it cannot set up vibrations. The gasifier, although symmetrically opposed, is not completely vibrationless, owing to gas inertia, but it requires only light and simple mountings. In this respect it certainly has very great advantages over a conventional piston type engine.

Automobile engineers may be reluctant to accept the automatic spring plate valves of the air compressor, but these have been developed to a high degree of efficiency and in France they are operating satisfactorily in power stations generating electricity and in propulsion units for ships. There is no reason why they should not be equally successful in road vehicles.



The cylinder bore and the crankshaft bearing sizes in the Jaguar 2.4 litre unit are the same as in the XK range of engines. As a result, many of the components are common and the new unit is of exceptionally sturdy design

The Jaguar 2·4 Litre Engine

A High-Performance Unit designed to give scope for further development

IMMEDIATELY after the 1939–1945 war, Jaguar Cars Ltd. began to develop their new engines designed to replace the existing range and to outstrip all competitors so far as performance was concerned. Originally, it was intended to produce four- and six-cylinder units for installation in two sizes of vehicle to supersede the earlier models, with which the firm had built its reputation. With both sizes, considerable success had been experienced in meeting competition, and a strong following of enthusiastic owners had been established. However, the emphasis on export, particularly to dollar markets, led to the decision to abandon the idea of producing the four-cylinder version. Subsequently, entry into markets all over the world, and the need to reduce costs by expanding production, have made it desirable to produce a smaller saloon car in addition to the well known models powered by the XK range of engines. This new vehicle is powered by the six-cylinder 2·4 litre engine, introduced last October.

Although the four-cylinder layout has a slight advantage so far as cost and weight reduction are concerned, the six-cylinder type, because of its inherent smooth running characteristics, is considered to be more suitable for cars of the quality associated with the name of Jaguar. Moreover, six-cylinder engines are more acceptable than four-cylinder engines in the North American market. Another reason for the adoption of the six-cylinder engine was that integral construction was to be employed in the car to give the greatest possible structural efficiency, and thus to reduce weight and improve performance. With this form of construction, the prevention of the transmission of vibrations, such as those due to the inherent secondary unbalance of four-cylinder engines, to the body is liable to be difficult.

SPECIFICATION

Six cylinders. Bore and stroke 83 mm and 76.5 mm respectively. Swept volume 2,483 cm^3. Maximum b.h.p. 112 at 5,750 r.p.m. Maximum b.m.e.p. and torque respectively, 140 lb/in^2 and 140 lb-ft at 2,000 r.p.m. Compression ratio 8 : 1 (7 : 1 optional). Forged, seven-bearing crankshaft, partly balanced. Overhead valves, actuated by two overhead camshafts. Twin solex downdraught B32-PBI-5/S carburettors, of the open-choke type, with 24 mm diameter choke. Hemispherical combustion chambers. S.U. electric fuel lift pump, type AUA 57.

To keep the prime cost to a minimum, it was decided that as many components as possible should be common to the XK and 2·4 litre ranges. Other incidental advantages have been obtained by following this policy of rationalization. One is that problems with regard to the supply of spares to all parts of the world are minimised. Also, the experience gained with the XK engines and the four-cylinder prototypes of the same basic design could be applied directly to the new engine.

In the new engine, the bore is the same as that of the XK unit, but the stroke is shorter and the connecting rod length has been shortened, so the ratio of connecting rod length: stroke is still 1·87 : 1. As a result, the height of the cylinder block has been reduced by $2\frac{11}{16}$in; this has considerably reduced the weight of the engine. The cylinder head is common to the XK and 2·4 litre units, as also are the crankshaft bearings. Because the bearings are of the same sizes as those used on the XK 140, and also because of the reduction in stroke, an exceptionally stiff crankshaft has been obtained. Evidently, further development to increase the speed and power output of the engine could be undertaken, should the manufacturers wish to do so later. In fact, the inlet valve lift is less than that of the XK, and the engine has been deliberately throttled at the carburettors and manifolds; therefore, the peak b.m.e.p. occurs at little over 2,000 r.p.m., whereas in the XK 140 it occurs at about 3,400 r.p.m.

The 2·4 litre engine has a stroke : bore ratio of 0·92 : 1, and its mean piston speed at maximum b.h.p. is 2,880 ft/min. The ratio of maximum torque : torque at maximum b.h.p. is 1·38 : 1, and the ratio of the speed at maximum torque : speed at maximum b.h.p. is 0·35 : 1. At 2,000 r.p.m., the maximum b.m.e.p. of 140 lb/in^2 is developed. The output in terms of b.h.p./in^2 piston area is 1·34, and 45 in terms of b.h.p./litre. Since the engine dry weight is 529 lb, the specific output is 0.212 b.h.p./lb. A minimum brake specific fuel consumption of 0·54 pt/b.h.p.–hr is obtained. The overall dimensions of the unit are as follows: height, less air filter, 27in; width, less air filter and dip stick, $18\frac{1}{4}$in; length, less flywheel, $33\frac{7}{8}$in. It is installed at an angle of 4 deg 19 min 54 sec from the horizontal.

Cylinder block and crankcase

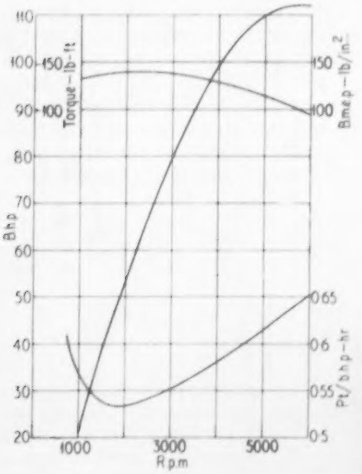
A chromium iron cylinder block and crankcase casting is employed. Since the bore diameter and the spacing between the cylinder axes are the same as in the units of the XK range, it has been possible to design the block of the new engine so that most of the machining can be done, together with that of the blocks of the other units, on one production line. Simplicity of block design, a minimum of machining and relatively light weight are, of course, all inherent characteristics of the cylinder blocks for engines of the overhead camshaft layout. Further weight saving, as has already been mentioned, has been effected by the reduction in stroke and connecting rod length as compared with the XK range, but the crankcase, of course, is still inevitably the heaviest unit of the whole engine.

The cylinder bores are integral with the block and their wall thickness is $\frac{3}{16}$in, while the minimum jacket space between the cylinders is $\frac{5}{32}$in. They are hone finished to 25–35 micro-in. It has not been necessary to employ liners, because of the rate of wear experienced with the XK range has been exceptionally low. In fact, the manufacturer states that the need for rebore does not arise during the normal first-owner life. It is believed that the long service obtained between rebores is mainly due to freedom from distortion of the cylinders. This is, again, an inherent characteristic of the overhead camshaft layout, which allows the block design to be more or less symmetrical round the cylinder bores and also enables the cylinder head holding down studs to be favourably positioned and adequately supported. The support for the studs is afforded by vertical ribs between each stud boss and the lower deck of the block. These ribs form a continuation of each side of the transverse webs below the lower deck, which carry the main bearings. Because of this reinforcement, the thickness of the upper and lower decks is only $\frac{5}{16}$in. The employment of chromium plated rings in the top grooves of the piston also increase bore life. Tests have shown that the reduction in bore wear obtained by using these rings is at least 50 per cent.

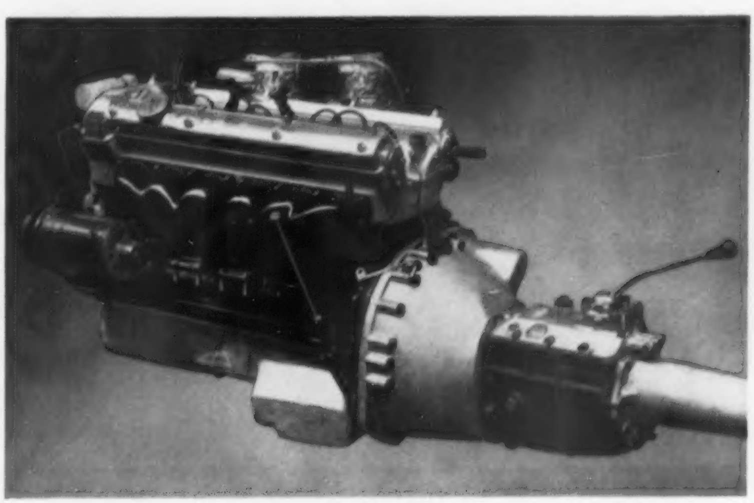
Although the deep skirted type of crankcase design is probably the best in some respects for a four-cylinder engine, this manufacturer considers that for a six-cylinder unit it is better to have the sump face joint at the level of the axis of the crankshaft. This is because, whereas in the four-cylinder layout a deep skirt gives greater stiffness to react the vertical out-of-balance forces, six-cylinder engines are inherently well balanced and it is preferable to have the additional stiffness of the face joint flange at the level of the crankshaft axis, where it increases the lateral stiffness of the block. Moreover, the deep skirted type of crankcase is inevitably heavier than the short skirted type unless lateral stiffness is sacrificed. An additional advantage of the short skirt is the simplicity of the machining operations at the lower face of the block. In this engine, the seats for the main journal bearing caps are not countersunk in the lower face of the block, so lateral location of the caps is effected by two $\frac{5}{16}$in diameter dowels, one on each side. To prevent the bearing caps from being fitted accidentally the wrong way round, their $\frac{1}{2}$in diameter En 16T bolts are arranged eccentrically relative to the crankshaft axis, and each pair of dowels is offset to the rear of the transverse plane containing the axes of the bolts.

Crankshaft, connecting rods and pistons

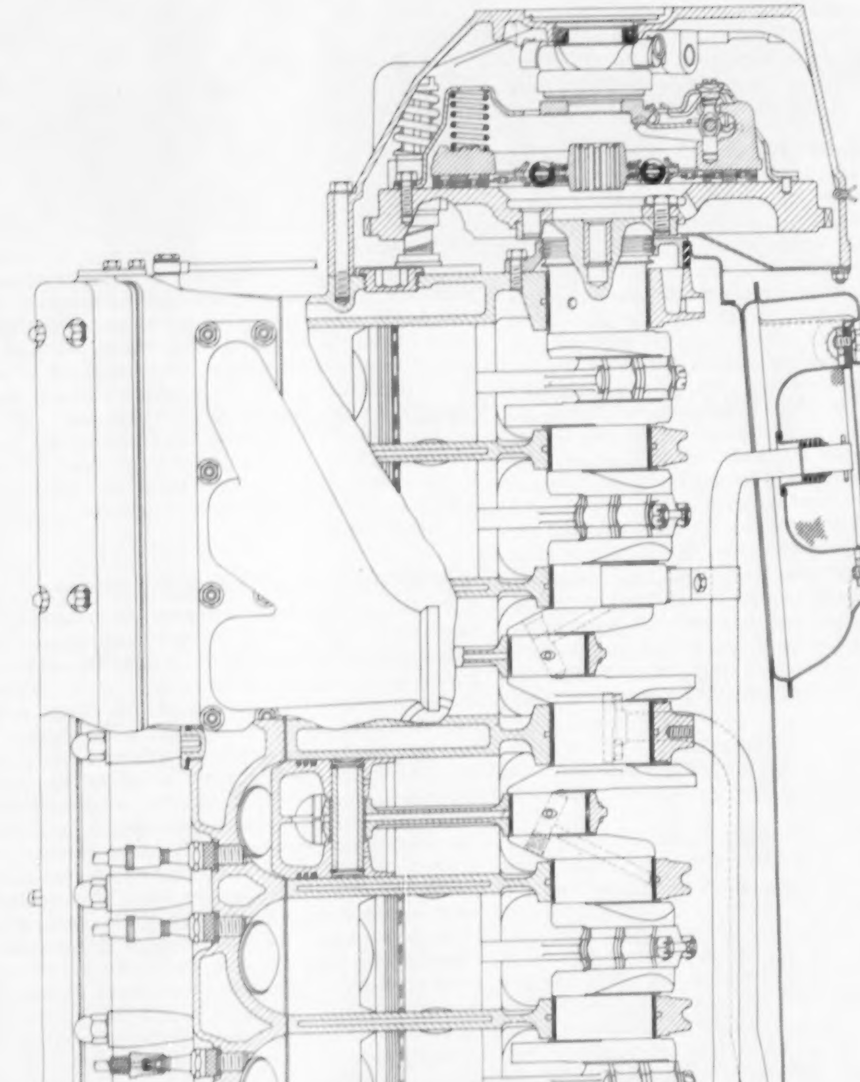
The En 16 crankshaft is of more or less conventional seven-bearing type of design. It is heat treated prior to machining to give a Brinell hardness figure of 270–295. A noteworthy feature is the large size of its bearings. The main journals are $2\frac{3}{4}$in diameter and their lengths are: front, centre and rear, $1\frac{1}{2}$in, remainder 1in. Vandervell D2 Bimetal, babbit-lined bearing shells are employed. Their diametral clearance is 0·0015–0·003in and they are a 0·001in nip fit in their housings. All the journals and pins are ground and hand lapped to a finish of about 10 micro-in. Axial location is effected at the centre main journal, where there are two semi-circular, babbit-lined steel thrust washers, one in front of and the other behind the bearing cap. The edges of the oil holes, where they break through the surface, are stoned away to form an oval countersink. This reduces stress concentrations and acts as a lead-in for the oil. Also, if sharp edges are left round the holes, there is a danger of small



Above: The engine performance curves



Right: Clean exterior lines are characteristic of all the Jaguar engines, including this 2.4 litre unit



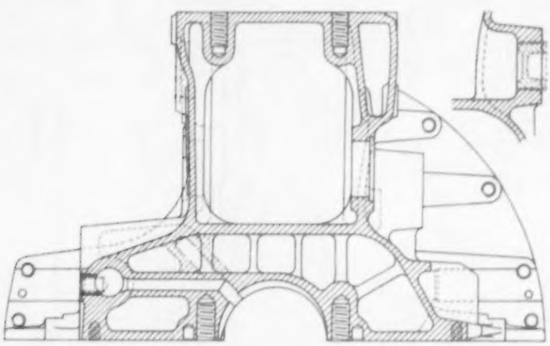
GENERAL ARRANGEMENT OF THE JAGUAR 2.4 LITRE ENGINE

Bore and stroke 83 mm × 76.5 mm. Swept volume 2,483 cm³

fragments of metal being broken off by the oil flow and damaging the bearings.

I-section connecting rods of En 16T3 are employed. They have a centre-to-centre length of 5$\frac{3}{4}$in. Their cross sectional dimensions are: width over flanges $\frac{13}{16}$in and depth 1in. Each rod, complete with the bearing cap, shell and bolts, weighs 1 lb. 9$\frac{1}{2}$ oz.

The big ends are split at an angle of 90 deg to the axis of the rod, but they are not too wide to be withdrawn through



Cross section of the cylinder block and crankcase casting, showing how the cylinder head holding down studs are supported. The scrap view illustrates the arrangement for installing an electric heater unit in the jacket, for countries with very cold climates

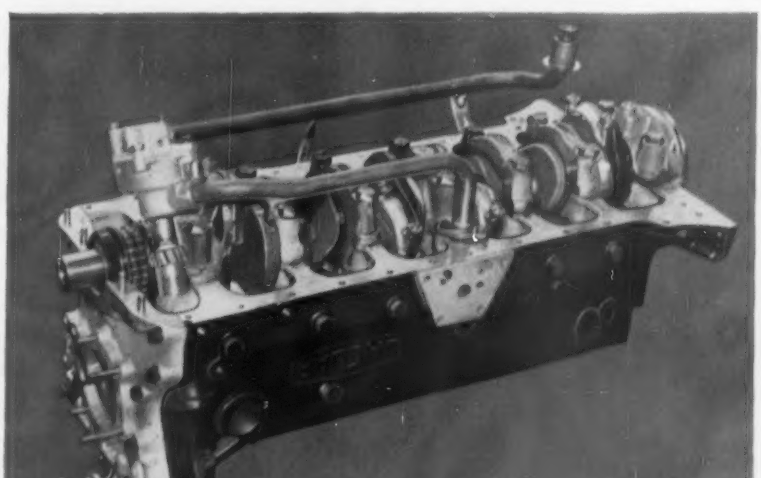
the bores of the cylinder. Each cap is located by the fit of its two $\frac{3}{8}$in diameter split-pinned En 24T retaining bolts. The shanks of the bolts are not waisted. Vandervell D2 Bimetal, white metal lined, steel shell type bearings are employed. They are 1in long and the crank pin diameter is 2·0863in. The diametral clearance is 0·0009–0·0025in and the nip of the bearing shells in the bearing housing is 0·001in.

A $\frac{5}{32}$in diameter radial hole in the upper half of the bearing shell communicates with a $\frac{7}{32}$in diameter duct drilled axially through the web of the rod. Although the duct breaks out at the top end of the rod, the oil cannot escape through the hole at this end since there is only one radial hole in the small end bush, and this hole is in line with the lower portion of the duct in the web. The bush is of Clevite 10 phosphor bronze and is 1·08in long. Its interference fit in the eye of the rod is 0·0035–0·0045in, and the diametral clearance between it and the gudgeon pin is ± 0·0002in.

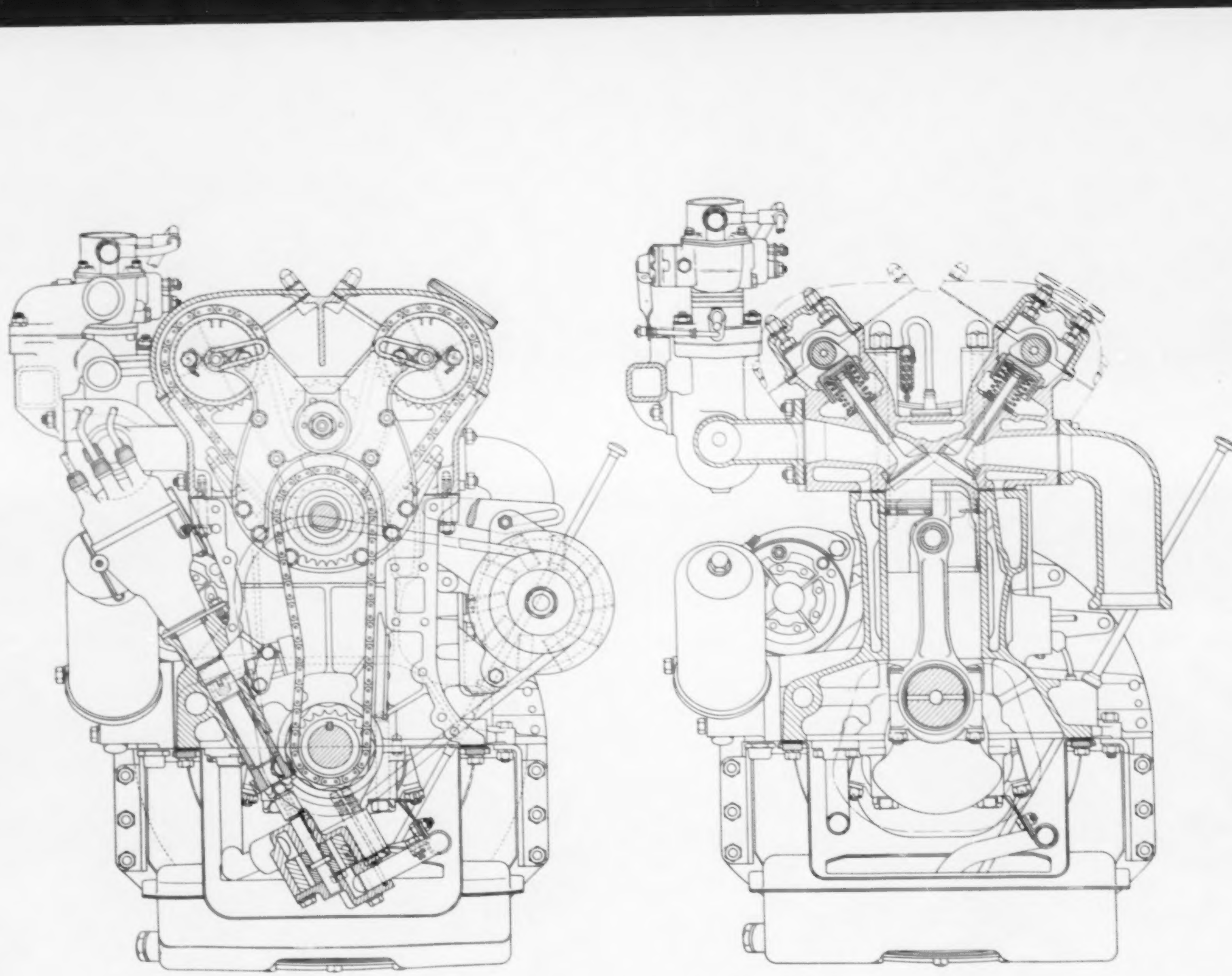
An En 34 gudgeon pin, case hardened 0·020–0·030in deep to C57–C63 Rockwell is employed. It is of plain cylindrical section with an inside diameter of $\frac{5}{8}$in and an outside diameter of $\frac{7}{8}$in. The surface finish is 4–5 micro-in. Seeger type circlips in grooves in the cross-holes axially locate the pin. The bearing length of the pin in each piston boss is $\frac{13}{16}$in and the diametral clearance between the pin and the boss is from +0·0001 to − 0·003in.

Brico, tin plated, AL.1 LX pistons of light construction are employed. Their weight, complete with gudgeon pins and rings, is 1 lb 3 oz 2 dm. They have flat crowns with chamfered edges to fit into the hemispherical cylinder heads and give a compression ratio of 8 : 1. A larger chamfer is machined on each side to clear the valves. The crown is stiffened internally by a single lateral web, and the loading is transmitted to the gudgeon pin bosses by two longitudinal ribs, one on each side of the bosses. A T-slotted skirt design, with the horizontal portion of the slot in the base of the oil ring groove, has been adopted. Three rings are fitted, two compression and one oil control, and all are above the gudgeon pin. Details of the rings are given in the accompanying Table.

The flywheel, which is spigoted over the flange on the rear end of the shaft, is an En 8 drop forging, and the 104-tooth starter ring gear is machined on its periphery. Its overall dimensions are 13·2in diameter × 1$\frac{13}{16}$in thick and its weight and mass moment of inertia are 27 lb 10 oz and 5·1 lb-ft^2 respectively. Ten, $\frac{7}{16}$in diameter high tensile steel bolts are used to secure it to the flange, and location is effected by two $\frac{3}{8}$in diameter dowels. The reason for using this large number of bolts is that if the clamping effect of the bolts were inadequate to prevent relative movement between the shaft and flywheel, the dowels alone would react the whole of the inertia loading in excess of that taken by the friction between the clamped faces, until the metal round them deflected sufficiently for the clearance in the bolt holes to be taken up. Only then could the bolts begin to take a share of the shear load.



Inherently good features of the cylinder blocks for engines of the overhead valve layout are simplicity of design, a minimum of machining and relatively light weight. Despite the difference in stroke between the 2.4 litre and XK engines, a considerable amount of rationalization has been effected, so far as the machining of the cylinder block and crankcase unit is concerned



CROSS SECTIONS OF THE JAGUAR 2.4 LITRE ENGINE

Relatively small half-speed wheels are used, because a two-stage, two strand chain drive has been adopted for the timing drive
The main journal bearing caps are located by dowels and their holding down bolts are offset to prevent incorrect assembly

The oil seal immediately in front of the flywheel is a return scroll machined round the crankshaft. This scroll is surrounded by a two-piece housing of cast aluminium. The upper half of the housing is bolted to the rear face of the crankcase, while the lower half is bolted to the upper one. An annular groove is machined in the bore of this housing and radial holes in the lower half drain oil from it, through the drainage space for the oil thrower in front of the scroll, to the sump. This arrangement is incorporated to deal with excessive quantities of lubricant that might suddenly flood the return scroll during violent acceleration of the vehicle. The rear end of the sump has a lipped, semi-circular cut-out in it, and the lip is pulled up against a rubber bonded cork strip in a groove round the lower half of the housing. A

Spider assembly carrying the timing drive chains and the intermediate and eccentric jockey sprockets

collar round the shaft between the return grooving and the rear journal bearing forms the oil thrower and works in a drainage space in the front end of the housing round the return grooves. Oil flung off the thrower falls to the bottom of the space and drains away through a hole drilled in the base of the bearing cap.

The shaft is only partly counterweighted to oppose the inertia loads of numbers 3 and 4 reciprocating masses. This is a compromise, because the addition of counterweights large enough to balance the loads fully would have introduced formidable problems with regard to torsional vibration. The counterweights are dynamically balanced by two more weights, one on number 2 web and the other on number 11 web. Particular care is exercised with regard to the balance of the complete assembly. First the shaft is dynamically balanced on an Avery machine. Next, the flywheel, which previously has been checked on a Micropoise Static Balancer, is fitted; the whole assembly is then corrected statically. A final check is made after the clutch has been bolted on.

The torsional vibration damper is a Metalastik rubber-to-metal bonded, inertia-ring type unit. It is spigoted, together with the fan belt pulley, on to a flanged, steel hub. This hub has a tapered bore and is pulled up on to a split cone on the front end of the crankshaft. The cone is keyed on to the shaft, and the hub is keyed to the cone. This arrangement is employed, of course, to ensure that there is no possibility of relative movement between the shaft and the hub of the damper.

Timing drive

At the front end of the crankshaft the extension is 4½in long × 1⅞in diameter. Assembled on to it in the following order are: the gear, of Fox 709 steel, for driving the oil pump and distributor, the En 8D(R) timing chain sprocket, a large diameter plain washer that acts as an oil thrower, a distance tube and the split cone that carries the 5in overall

PISTON RING DATA

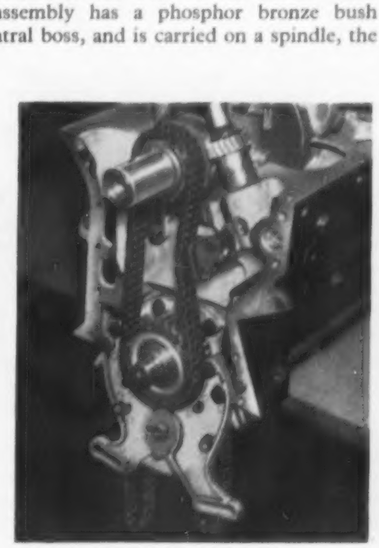
	Top	Second
Compression rings:		
Type	Plain chromium plated	Plain oxidized
Gap	0·020–0·015in butt joint	
Face width	0·0787–0·0777in	
Radial thickness	0·130–0·124in	
Depth of groove in piston	0·136–0·131in	
Side clearance	0·003–0·001in	
Oil control ring:		
Type	Slotted scraper ring	
Gap	0·016–0·011in butt joint	
Face width	0·156–0·155in	
Radial thickness	0·127–0·119in	
Depth of groove in piston	0·136–0·131in	
Side clearance	0·003–0·001in	

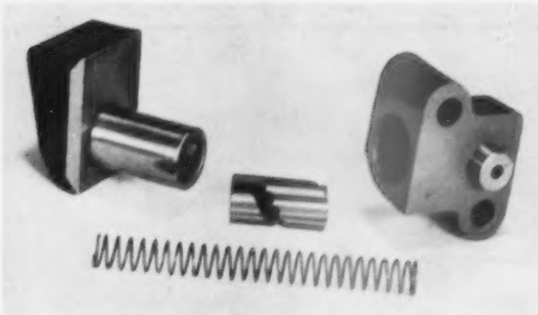
diameter aluminium, fan belt pulley, and torsional vibration damper assembly. The whole assembly is retained by a $\frac{9}{32}$in thick washer and a ¾in diameter set bolt screwed axially into the front end of the crankshaft extension. Of the three Woodruff keys transmitting the drive to the components, that at the rear drives the oil pump gear, and that at the front drives the damper cone, while the centre one, which drives the chain sprocket, also projects about $\frac{1}{16}$in forward of the sprocket into keyways in the thrower disc and the distance tube. A lip type oil seal bears on the distance tube. It is carried in a channel section housing in the front cover of the cell at the forward end of the crankcase, in which the timing chain is enclosed.

The upper portion of the timing case is formed by a cell cored in the front end of the cylinder head casting. There are three bolted-on covers on the cell, one above each half speed wheel and one on the front. The two-stage form of chain drive adopted has the disadvantage that it increases the overall length of the engine, but it has a number of marked advantages. Not least among these is the fact that some of the speed reduction can be made at the intermediate sprocket. Therefore, much smaller diameter camshaft sprockets can be employed and so the timing case does not have to be so wide as with the single-chain layout.

Two ⅜in pitch, double-row chains are employed: one transmits the drive from the crankshaft sprocket to an idler, whence the other takes the drive on to the two half speed wheels. The idler comprises two sprockets, one keyed on to a forward extension of the boss of the other. This double sprocket assembly has a phosphor bronze bush pressed into its central boss, and is carried on a spindle, the

Front cover removed to show the timing drive and chain tensioning arrangements





The components of the Renold hydraulic chain-tensioner

axis of which is $8\frac{1}{4}$in above that of the crankshaft. The centre-to-centre spacing between it and each half speed wheel is $6\frac{7}{8}$in. A noteworthy feature of the assembly is that the sprockets are at the ends of the arms of a Y-shaped spider, bolted to the front wall of the cylinder block. This spider is used to carry the half speed wheels and their chains when the cylinder head or camshafts are removed, so that servicing operations can be performed on the head without disturbing the valve timing.

The central portion of the spindle on which the intermediate sprocket assembly is carried is $\frac{15}{16}$in diameter. Its front end is reduced to $\frac{7}{8}$in diameter where it is carried in a hole in the front cover, and its rear end is reduced to $\frac{13}{16}$in diameter. The rear end projects through a hole in the back plate of the spider and is spigoted into another hole in the front wall of the cylinder block. The hole in the block locates the spindle relative to the crankshaft. Axial location of the spindle is effected by a circlip in a groove round its rear end; this circlip seats in a shallow counterbore round the hole in the cylinder block, in which it is retained by the back plate of the spider. The sprocket assembly is located between the back plate and a collar formed round the forward end of the large diameter central portion of the spindle.

Directly above the intermediate spindle is the eccentric jockey sprocket for the upper chain. This sprocket is mounted between the spider and its back plate. The eccentric is $1\frac{5}{16}$in diameter and the ends of the spindle, where they are carried in the spider and back plate, are turned down to $\frac{3}{4}$in diameter. At the front end, the spindle projects through the hole in which it is carried in the spider, and a flat is machined on its periphery. This flat locates a large diameter washer, which has a corresponding flat in its bore, to register against that on the spindle; thus, rotation of the washer also rotates the eccentric. The whole assembly is retained by a nut, which is screwed on to the front end of the spindle.

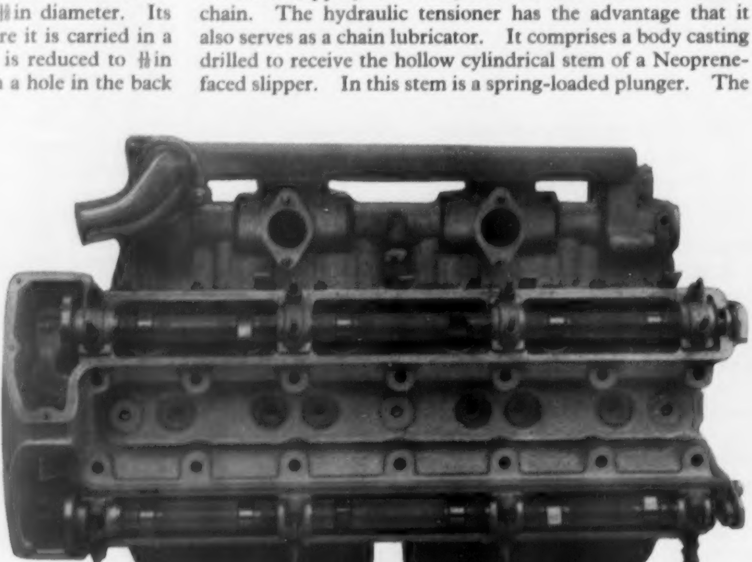
To lock the setting of the eccentric, the periphery of the washer is serrated and located against rotation by a spring-loaded plunger in a blind hole in the spider. This plunger has a flat machined at its front end. The serrations that lock the setting are cut on the flat and then their front ends are machined off so that only a short length remains to engage those round the washer. Thus, to adjust the setting of the eccentric, it is not necessary to undo the nut on the front end of the spindle: instead, the plunger is pushed into its housing until the serrations disengage and the washer is in line with the flat in front of the serrations on the plunger. Then the washer, and with it the eccentric, can be rotated to effect the adjustment. Finally, it is locked again by releasing the plunger, which springs out so that the serrations engage. Access to make this adjustment is gained by removing the cover on the front of the cell in which the timing gear is housed.

A Renold hydraulically-actuated, slipper type tensioner takes up the slack in the lower chain, and a nylon-faced, fixed slipper steadies the drive side. Both the tensioner and the fixed slipper, of course, bear on the outer face of the chain. The hydraulic tensioner has the advantage that it also serves as a chain lubricator. It comprises a body casting drilled to receive the hollow cylindrical stem of a Neoprene-faced slipper. In this stem is a spring-loaded plunger. The whole assembly is bolted to the front wall of the crankcase, with the axis of the stem of the slipper normal to the strand of the chain.

The coil spring, which seats at one end in the piston-shaped plunger and at the other in the closed outer end of the stem of the slipper, is in compression so that it forces, the slipper against the chain. When the engine is running, lubricating oil from the main gallery passes through a metering hole into the body of the tensioner and, since it is under pressure, adds to the force of the spring in pushing the slipper against the chain. There is also a bleed hole, drilled axially through the outer end of the stem of the slipper and through the Neoprene facing, to lubricate the chain.

The plunger is simply a rachet device to limit the motion of the slipper assembly away from the chain. In its side

A view of the cylinder head, with the camshaft covers removed, illustrating the simplicity of the overhead camshaft design from the point of view of both layout and assembly of the valve actuating gear on the head



there is a spiral slot in which is registered a peg projecting radially inwards in the end of the bore of the hollow plunger. One edge of this slot is serrated in such a manner that if the slipper is forced inwards against the hydraulic pressure and the spring, the peg moves until it seats in the nearest serration so that further movement is prevented. As extension of the chain takes place, the stem is pushed outwards stage by stage and the peg, sliding in the spiral groove, rotates the plunger. This brings fresh serrations, one after the other, in line with the peg and thus locks the plunger progressively further and further out. Tension in the upper chain is adjusted by the eccentric jockey sprocket meshing against the outer face of the strand between the two camshaft sprockets. On each flank of the chain, a nylon-faced brass slipper, bolted to the cylinder block, steadies the sections between the intermediate and camshaft sprockets.

Each camshaft sprocket is an En 8D(R) ring spigoted on to a flange at the front end of the camshaft. The teeth are machined on the outer periphery, and there is an internally serrated flange in the bore. A disc with serrations on its periphery, to engage those in the internal flange, is spot welded to a retainer plate, and the whole assembly is secured to the camshaft by two set bolts. Thus, the retainer plate clamps the internal flange of the sprocket against the front face of the flange at the forward end of the camshaft. A circlip in a groove in front of the retainer in the sprocket prevents the serrations from sliding out of engagement when the assembly is withdrawn from the camshaft flange. There are 131 serrations; this makes possible an adjustment of as little as 1 deg 22 min to the timing of the valves. A short shouldered spindle is spigoted into a hole in the centre of this plate assembly and is retained by a Belleville washer and a circlip in a groove round its rear end. The front end of the spindle is threaded and reduced in diameter to project through a slotted hole in the arm of the spider to which, if the camshaft is removed, the spindle and plate assembly is clamped by a slave nut. Thus, the sprocket is free to rotate if for any reason the engine has to be turned while the head is off.

If a camshaft has to be removed, the two set bolts that secure the sprocket to the shaft are unscrewed and a slave nut is assembled on to the end of the central spindle to withdraw the sprocket and clamp it on to the end of the spider arm. Then the shaft can be taken away and replaced again without altering the setting of the valve timing. When the camshafts are replaced, the crankshaft is first set so that No. 1 piston is at T.D.C. Then the camshaft setting relative to the crankshaft is fixed by means of a special gauge. This gauge is located on the upper joint face on the head and has a tongue that registers in a slot in the flange round the camshaft, immediately behind its front bearing. If the whole of the head assembly has to be removed, both camshaft sprockets have to be withdrawn in the same way. However, in these circumstances, they must be slid towards each other along the slots in the spider arms; otherwise, when the assembly is removed, they will not clear the sides of the cell in the head.

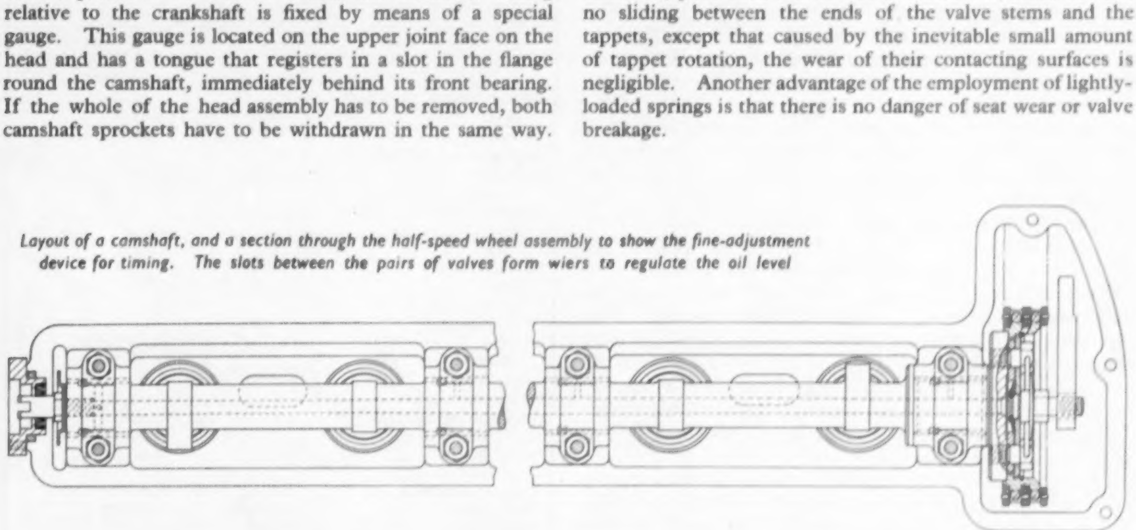
Camshaft and valve gear

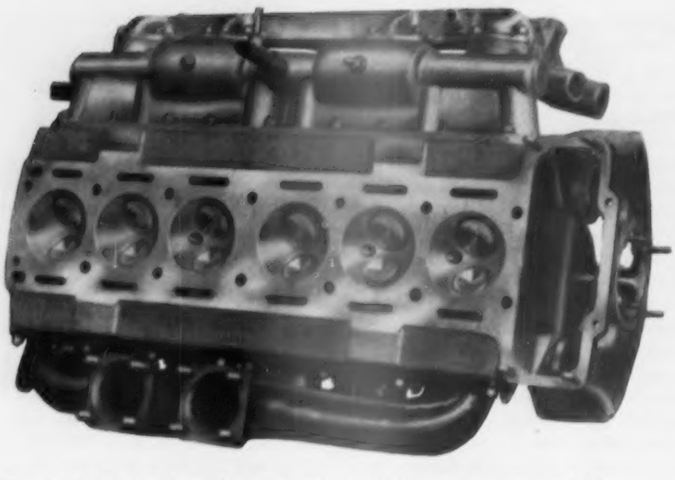
The advantages of the twin overhead camshaft layout adopted are as follows. Since there are no rockers, and the side thrust from the cams is taken by the tappets interposed between them and the valve stems, the rate of wear of the valve stems and guides is practically zero. This is a noteworthy feature because it eliminates the possibility that wear will cause excessive clearances to develop between the stems and guides. Excessive clearance particularly on the exhaust side, of course, impedes the flow of heat from the valve, and as a consequence, overheating occurs and tends to burn the relatively large amounts of oil that get into these big clearances. The resultant accumulation of carbon, and the side thrust on the valve stems, is liable to cause valve sticking—a trouble which the Company say is unheard of on these engines. Another feature that helps to prevent the passage of too much oil down the stems is the employment of piston type tappets over the upper ends of the valve and spring assemblies.

Adjustment of the tappet clearances is effected by interposing hardened En 24Z steel washers of appropriate thicknesses between the tappets and the valve stem ends. In service, this is done as follows. First, the existing clearances at each tappet are checked and recorded. Then the camshaft is removed and the thicknesses of the discs between the tappet and valve stem ends are measured. By comparing these measurements with the recorded clearances, it is a simple matter to calculate the thicknesses of the replacement discs that must be inserted to correct the clearance. After the new discs have been fitted, the camshafts are reassembled in the head. The whole sequence of operations can be done either *in situ* or with the head removed and placed on a bench.

The reason why this disc and tappet arrangement can be employed is that adjustment is necessary only at infrequent intervals. This is because with the twin overhead camshaft layout, the total weight of the reciprocating components of the valve train is low and the valve spring load is light. Therefore, for any given speed, the loading of the rubbing surfaces of the cams and tappets is only about half that obtained with the conventional layout comprising a low camshaft, push rods and rockers. Moreover, since there is no sliding between the ends of the valve stems and the tappets, except that caused by the inevitable small amount of tappet rotation, the wear of their contacting surfaces is negligible. Another advantage of the employment of lightly-loaded springs is that there is no danger of seat wear or valve breakage.

Layout of a camshaft, and a section through the half-speed wheel assembly to show the fine-adjustment device for timing. The slots between the pairs of valves form wiers to regulate the oil level





The arrangement of the combustion chambers, and inlet and exhaust manifolds

Four, Vandervell D2 Bimetal, white metal lined, steel shell type, plain bearings carry each Monikrom cast iron camshaft. All are 1 5/16in long × 1in bore and the diametral clearance is 0·0005–0·002in. They are carried in housings machined directly in the cylinder head casting and are retained by caps secured by two 5/16 diameter studs. Extensions of these studs also secure the cast aluminium alloy cover on top of the camshaft housing. The interference fit between the bearing shells and their housings is 0·001in. Axial location is effected at the front end, where the bearing housing is between two flanges round the shaft. Both shafts are 15/16in diameter between the cams and they have 5/16in diameter holes drilled axially through them. Radial holes, 3/32in diameter, feed oil to the bearings.

The lift of the inlet cam is low, by comparison with that in the XK range; this is to restrict the breathing. On the inlet side, the lift is 5/16in, and the nominal period is 240 deg. At 6,000 r.p.m., the maximum positive acceleration of the tappet, on the flank of the cam, is 20,800 ft/sec^2 and the maximum negative acceleration, on the nose, is 6,400 ft/sec^2. On the exhaust camshaft, the lift is also 5/16in, but the nominal period is 252 deg. A maximum positive acceleration of 30,900 ft/sec^2 is obtained and the maximum negative acceleration is 5,620 ft/sec^2. The cam profiles are chilled to a Rockwell hardness figure of C50–51.

The valves are set at an included angle of 70 deg, the axes of each pair being in the same transverse vertical plane as the axis of the cylinder that they serve. Their material specifications are given in the accompanying Table. The tappets are of chilled cast iron. They operate in flanged guides pressed into housings in the head. These guides are of austenitic iron because the high coefficient of expansion of this material helps to maintain the interference fit between them and their housings in the aluminium alloy head. There is a diametral clearance of 0·0019–0·0008in between the tappets and the 1 3/8in diameter bores of their guides.

Each valve has two springs, which are located radially by their shouldered retaining washers. Split tapered collets lock the assembly to the valve stem in the normal manner, and the hardened steel disc that is interposed between the end of the stem and the tappet is located radially in a counterbore in the upper end of the retaining washer. A circular, dished steel pressing forms the seating for the lower end of each pair of valve springs.

Cast iron valve guides are fitted. They are of a simple cylindrical section that can be finished by centreless grinding. The inlet and exhaust guides are not interchangeable because their lengths are different. At the lower ends of the guides, only the outer periphery is chamfered to remove the burrs without appreciably reducing the cross section. On the other hand, the upper end of each guide is completely chamfered to form a knife edge round the bore. This knife edge scrapes most of the oil film off the stem and prevents an excessive quantity of lubricant from passing into the guides. At this end, the reduction of cross section, due to the large chamfer, does not matter because, unlike the lower end, it is not subject to high temperatures. Before the guides are assembled into their housings, the head is heated to 80 deg C, so that the aluminium is not scored during the pressing-in operation.

Both the inlet and exhaust valves are of the modified tulip type, which gives a favourable shape to the gas passage in the port, and therefore good flow characteristics. Also, when the valves are running hot under heavy loading, this type retains its seat shape better than the flat-headed valve. Heat dissipation evidently has not been a serious problem, probably owing to the use of an aluminium head. A 30 deg seat angle has been adopted for the inlet valve, while the angle of the exhaust valve seat is 45 deg. This arrangement is considered to offer the best compromise, since it meets the requirements for smooth flow through the inlet valves and good seating of the exhaust valves to prevent blow-by. Both

VALVE DATA

	Inlet	Exhaust
Material	Silicon chrome steel En 52	Austenitic steel Fox 1282
Head diameter	1 3/4in	1 7/16in
Throat diameter	1 5/8in	1 1/4in
Stem diameter	5/16in	
Diametral clearance in guide	0·004–0·002in	
Seat angle	30 deg	45 deg
Face width;		
on valve	0·1538in	0·142in
on seat	0·076in	0·1989in
Seat material	Brimol centrifugally cast	
Spring material	Spring steel En 49D	
Spring rate;		
inner	69·3 lb/in	
outer	77·4 lb/in	
Spring length, free;		
inner	1·515in +0·020in −0·000in	
outer	1·775in +0·055in −0·000in	
Spring length, installed;		
inner	1 7/32in	
outer	1 5/16in	
Spring surge frequency;		
inner	24,200 c/min	
outer	19,560 c/min	
Number of coils;		
inner	6	
outer	5	
Coil diameter;		
inner	0·74in	
outer	1in	
Wire gauge;		
inner	12 S.W.G. (0·104in)	
outer	10 S.W.G. (0·128in)	
Valve lift	5/16in	
Valve crash speed	7,000 r.p.m.	
Valve guide material	Cast iron bar 2K11 or NC	
Valve guide length	1 13/16in	1 15/16in
Valve guide inside and outside diameters	5/16in 1/2in	
Tappet clearance	0·004in cold	0·006in cold
Valve opens	10 deg B.T.D.C.	57 deg B.B.D.C.
Valve closes	50 deg A.B.D.C.	15 deg A.T.D.C.

valve stems are undercut; the undercut on the inlet valve is 0·031in on the diameter and extends up to a level about ½in below the lower end of the guide; that on the exhaust is 0·020in on the diameter and extends to about $\frac{3}{16}$in above the lower end of the guide. The object of the undercut is to form a scraping edge to keep the lower ends of the guides free from carbon.

Brimol austenitic cast iron valve seats are fitted. This material, which has a high percentage nickel content, has a coefficient of thermal expansion of 0·000018/deg C, as compared with that of 0·000012/deg C for a straight cast iron, and 0·000022/deg C for D.T.D. 424. Although the cost of austenitic iron is greater than that of a straight iron, its high coefficient of expansion is a material advantage for seats to be fitted in an aluminium head. Before the seats are fitted, the head is preheated to a temperature of 150 deg C. The preheating both for fitting the seats and the guides is done in a controlled muffle furnace. A simpler method of fitting these components would have been to freeze them and insert them into the head without preheating it, but this is impracticable because a change in the properties of austenitic iron takes place at low temperatures. Although the exhaust valve seats are of plain rectangular section, with an internal chamfer machined in each to form a seating face, the bores of the inlet seats are shaped to form a continuation of the valve throat profile, and thus to give efficient breathing.

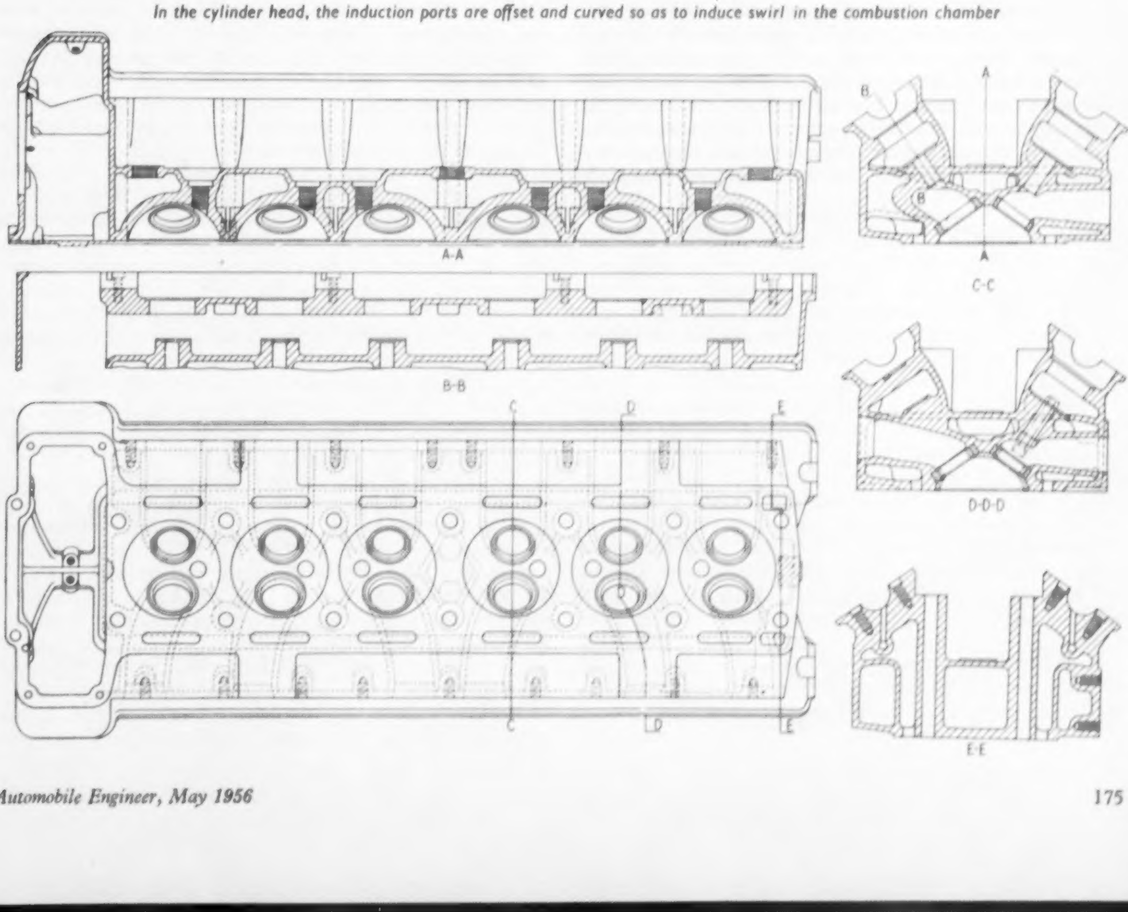
Cylinder head

An aluminium alloy head has been used for two main reasons. One is its high thermal conductivity and the other is its light weight. The complete head assembly weighs 50 lb, whereas had the casting been of iron, the weight would have been about 120 lb. Other advantages are the machineability of the aluminium and the ease with which the head can be handled at all stages of the production. A disadvantage is the extra care needed to avoid damaging the component when it is being handled on the production line. However, this can be largely overcome by taking a cut of 0·020in from the joint face after all other operations on the head have been completed. Before it was finally decided to use D.T.D. 424, a low expansion alloy was tried, but was rejected because of its high cost and not entirely satisfactory machining characteristics. The slightly lower rate of conductivity of this alloy was not considered to be of major importance. There has never been any sign of the seats working loose, even in the most highly rated XK units, so the decision to use D.T.D. 424 is justified.

The design of a cylinder head to be made of aluminium calls for the exercise of a certain amount of skill to avoid distortion. An important requirement is that the metal round the valve seats and guides shall be symmetrically disposed. Another is that the internal ribbing and the holding down bolts shall be suitably positioned. The tendency for distortion to occur arises from two main causes. Of these, the first is the load applied to the head by the holding down bolts, and the second is the differential rates of expansion between the relatively large and continuous mass of metal immediately beneath the camshafts, and the light arched sections of the combustion chambers and lower joint face.

Hemispherical combustion chambers are employed. This form of chamber is undoubtedly the best if a high b.m.e.p. is the most important requirement. Its advantages are as follows. Large diameter valve seats can be accommodated and, because of the tendency of the hemisphere to blend with the contours of the valve throat, the whole of the annular area between the head and the seat when the valve is open can be made effective; therefore, the gas flow is as good as can possibly be obtained. An unimpeded flow of cooling water to the exhaust valve seats is obtainable because of the favourable relationship between the ports and the jacket walls. Machining is simple; for this engine, a single form-cutter rotating about a fixed centre is employed. If the turbulence is properly controlled, and the sparking plug

In the cylinder head, the induction ports are offset and curved so as to induce swirl in the combustion chamber



is reasonably near the centre, the combustion characteristics of the hemispherical head are the best obtainable.

Pre-ignition and running-on have not been experienced with this combustion chamber. Some authorities maintain that the hemispherical head is inherently free from these troubles. Others* hold that running-on is a function of charge temperature; the reasons they give are as follows. If an engine running at its working temperature is switched off, the gas flow velocity in its induction manifold falls steadily, so that the heat picked up from the manifold and its jacket or hot-spot is greater; the fall in water pump delivery reduces the rate of thermal transfer from the cylinder head to the coolant; more time is available for pre-combustion reactions and for the charge to be heated by combustion chamber hot-spots. It is possible that the reason why the Jaguar is free from running-on troubles is that its aluminium head, water-circulated manifold heater and steel gasket are particularly effective in dissipating the heat and maintaining the temperatures at a moderate level.

The overall cross sectional dimensions of the casting are 5 $\frac{13}{16}$in deep × 8 $\frac{13}{16}$in wide, except at the front end, where they are 7 $\frac{1}{4}$in deep × 11 $\frac{3}{4}$in wide to clear the timing drive. Although these dimensions are fairly large, and a smaller and lighter head could have been designed, it was considered to be important to obtain a certain length of port so that the best possible gas flow could be maintained consistently. The head is held down by fourteeen studs of En 16T, tightened with torque wrenches set to slip at 54 lb/ft. Their threaded ends are $\frac{7}{16}$in diameter and they are waisted to 5in diameter, both to reduce stress concentrations at the threads and also to avoid electrolytic corrosion due to contact between the steel and aluminium. The studs fitted to the head have A.N.C. threads at the ends that are screwed into the aluminium and A.N.F. threads at the other ends.

In the early stages of the development, because there are considerable advantages in using as thin a gasket as possible, a $\frac{1}{32}$in thick gasket of an asbestos compound was employed. However, this had several disadvantages, one was that when it was being removed, it tended to break, and pieces truck to the castings and had to be scraped off. Although this trouble can be overcome by the application of a special compound, it was decided to use a cupro-nickel gasket, 0·010in or 0·015in thick, with corrugations pressed in it to form the seals. This gasket was entirely satisfactory, for normal operation, but under exceptionally heavy loading experienced in racing and other competition work, it was found that an even stronger one was necessary. Therefore, a similar type of gasket, but of steel, was developed in conjunction with Coopers Mechanical Joints Ltd. This gasket is about 0 015in thick and the corrugations pressed in it are deeper than those of the cupro-nickel one. Gaskets of this type have been used successfully in the XK engines with compression ratios up to 12 : 1.

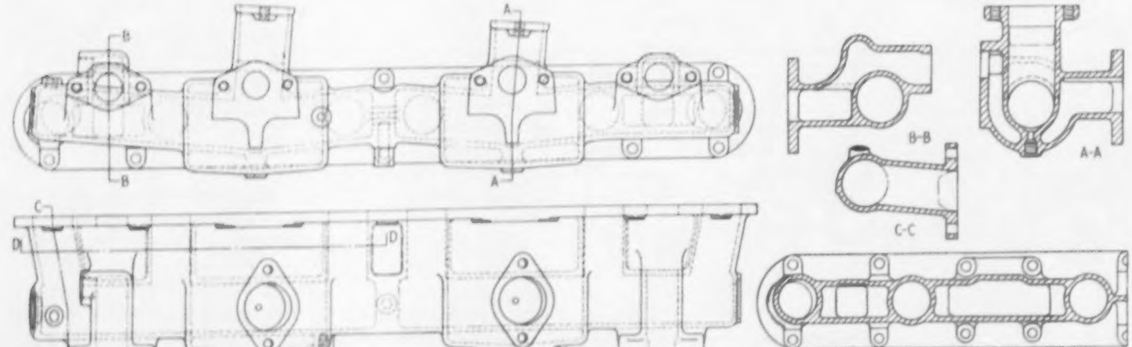
Weslake and Co. Ltd. carried out the design and development of the cylinder head and valve ports. This work was based mainly on flow tests carried out on full scale models of either wood or aluminium. Adjustments to the port shapes and sizes were made until the maximum flow was obtained. This method of obtaining the port shape represents a considerable economy in development time, as compared with the method of repeated bench tests. Moreover, by the application of this technique, it is almost invariably possible to improve the output of any engine by about 10 per cent. A larger valve or higher lift does not necessarily produce a greater flow; also, very small changes in port shape can materially effect the flow characteristics. Therefore, to avoid errors in transferring the shape from the model to the drawing and then from the drawing to the pattern, cores were made accurately from the model and supplied to the pattern makers. As a result, the production ports are in no way inferior to the master port.

From the illustration showing the cross section of the engine, it might at first sight appear that the water jacket space round the exhaust valve guides is inadequate. However, it should also be observed that the guides are surrounded by relatively large masses of aluminium, which has a high thermal conductivity and therefore allows the heat to pass freely to the surrounding jacket areas. The manufacturer states that the most important requirement is to design the jacketing round the exhaust valve seats, guides and ports in such a way that the flow of water is relatively fast. This prevents local overheating due to the formation of vapour in stagnant pockets of water.

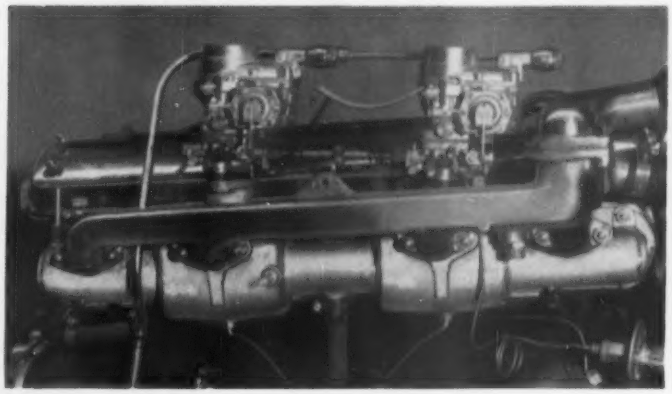
The axes of the exhaust ports, as viewed from above, and the centres of the inlet valve seats, are in transverse planes normal to the longitudinal centre-line of the block and in line with the points of intersection of that centre-line with the cylinder axes. However, the axes of the outer ends of the inlet ports are offset $\frac{11}{16}$in from that plane and their inner ends are swept round to the seats so that the flow into the combustion chamber is directed tangentially relative to the cylinder bores. The sparking plug in each cylinder is directly in the path of this tangential flow. In other words, it is not in line with the axis of the cylinder, but is offset along the longitudinal centre-line of the head. This not only gives good combustion characteristics, but also avoids

* D. Downs *and* J. H. Pignéguy: "*Experimental Investigation into Pre-Ignition in the Spark Ignition Engine*", Proc. I.Mech.E., Automobile Division, *1950–51.*

There are two tracts in the induction manifold, one beneath each riser, and they are arranged in such a way that under cold starting conditions, any fuel that collects in them is immediately drained awat



Right: Two Solex B32-PBI-5/S, downdraught, open-choke carburettors are fitted, and they are each equipped with a hand-operated strangler coupled with a fast idle system



Below: A view of the engine installation showng how the intake to the air cleaner and silencer is taken through a hole in the wing valance panel; thence it goes to a small grille at the front of the vehicle

limiting the sizes of the valve throats to accommodate the sparking plug between the seats. Although the cylinder head casting is not given any heat treatment other than for stress relief, it has not been found necessary to use inserts to receive the sparking plugs.

Carburettors, induction and exhaust systems

Two, Solex downdraught, B32-PBI-5/S, open-choke carburettors are fitted. They are equipped with a hand-operated strangler coupled with a fast idle system. A choke diameter of 24 mm has been adopted. Fuel is supplied from the 12 gallon tank by an S.U. electric high-pressure pump. A long, cylindrical type air cleaner and silencer of AC manufacture is employed. It is fitted on an inverted T-shaped duct of rectangular cross section, which fits over the intakes of the two carburettors. The air is drawn in through a duct from a small grille on the front panel of the body. This not only improves volumetric efficiency by taking cold air, but also assists in silencing the intake.

A cast aluminium alloy induction manifold of the straight rake-type is employed and a water rail of the same material is bolted to it. This rail has four flanged ports along its length. Two are the outlets from the head through the water jackets round the junctions between the risers and the induction gallery, while the other two, one at each end, are outlets from the cylinder head through cored ducts over the induction gallery in the manifold.

Both downdraught risers are fairly long and are at right angles to the induction tract, which is of circular cross section. The front riser is between the induction branches of the pairs of cylinders numbers 2 and 3, and the rear one is between numbers 4 and 5. Thus, each carburettor serves three cylinders. Between the portion of the tract that serves the front three cylinders and that which serves the rear three is a ½in diameter balance orifice. Because of the transmission angle of the engine, the riser for the rear carburettor is longer than that for the front one, and the main tract is so arranged that, when the engine is installed, the floor of the tract to the rear of each riser is horizontal, while the floor in front of each riser slopes down towards the T-junction. This prevents liquid fuel from collecting at the rear end of each half of the tract under cold starting conditions. A drain tube is provided under each of the risers.

Two three-port cast iron exhaust manifolds are fitted. As viewed from the side of the engine, the branch ports of cylinders numbers 3 and 4 are vertical, while those of numbers 1 and 2 and numbers 5 and 6 are inclined inwards to join them. About 6in from the flanges at the lower ends of the two manifolds, the down pipes join a single pipe, which leads to an elliptical section exhaust silencer. The employment of two separate exhaust manifolds, rather than having all the cylinder head ports discharging into a single manifold, adds to the efficiency of the unit, and there is less likelihood of trouble due to thermal expansion.

Water pump and cooling system

The water pump is of conventional design but, nevertheless, considerable work has been done on it in the development stage, largely to prevent cavitation at high speeds. The pump runs at 0·9 times engine speed, mainly because of the requirements of the 15in diameter, four-bladed, pressed steel fan, the cast iron boss of which is pressed on to the front end of the spindle. A ⅜in wide × $\frac{5}{16}$in thick V-belt, the included angle of which is 38 deg, drives the D.T.D. 424 pulley spigoted on the fan boss.

The spindle is a plain cylindrical component, ⅝in diameter, so that it can be finished by centreless grinding. There are three grooves in it; two, spaced $1\frac{3}{16}$in apart, form the inner races for the ball bearings and the third locates a rubber thrower ring that operates in a drainage space between the bearing assembly and the water seal. A single tubular component forms the outer races of the two rows of ball bearings; it is sealed at each end to prevent the entry of corrosive or abrasive matter. Location of the assembly is effected by a conical-ended grub-screw, with a lock nut, assembled radially into a tapped hole in the cast iron nose piece of the pump body to register in a hole in the tubular outer race.

A conventional spring-loaded rubber water seal, supplied by the Morgan Crucible Co. Ltd., is employed. It is housed in a pressed brass cup in an aperture in the front wall of the water inlet volute and has a graphite ring bonded to its rear face. This ring bears on the front end of the rotor boss The rotor is of B.S. 1452 grade 10 annealed cast iron and is $2\frac{1}{4}$in diameter. It has only four vanes which, to prevent cavitation, are arranged spirally instead of radially. Their inner ends, that is, between the boss and the portion shrouded by the front wall of the impellor housing, are machined away. This feature prevents shock at the entry, where the water flow changes from the axial to the radial direction. Further improvement of the flow characteristics is obtained by streamlining the leading edges of the blades. The pump body forms only the front cover of the rotor housing, the main portion of which is cored in the front face of the aluminium alloy, timing drive cover.

The water flows from the pump outlet into a gallery cored, on the exhaust side, in the upper portion of the cylinder block. From this gallery the water passes vertically through ducts in the block and cylinder head casting; these ducts direct the flow round the exhaust valve seats and guides. Thence it passes transversely across the head, past the inlet valve ports and out through four holes in the side of the head. A thermosyphon circulation through ducts between the inlet side of the head and block cools the cylinder barrels. Two of the outlet holes in the side of the head lead into the jackets round the junction between the induction manifold risers and the main tract, whence the water passes into the outlet rail; the other two, one at each end, lead directly into the water rail. Cast integrally on the front end of the rail is the housing for the thermostat valve. There are, of course, two outlets from this housing, one to the pump inlet and the other to the radiator.

The capacity of the cooling system is 20 pints. A finned tube radiator is employed. Its frontal area is 293in^2, and the thickness of the block is 70 mm (2·75in). An AC valve is fitted to maintain the pressure in the system at 4 lb/in^2. The thermostat lifts at 70–75 deg C.

Oil pump and lubricating system

A Hobourn-Eaton pump is partly submerged below the oil in the sump. The outer rotor is $2\frac{1}{4}$in outside diameter and both are $1\frac{3}{16}$in long. The pump drive spindle, which rotates at half engine speed, is $\frac{1}{2}$in diameter × $3\frac{3}{4}$in long; it is secured to the rotor by a $\frac{3}{16}$in diameter peg. At the upper end, where the spindle projects through the pump casing, it is machined to form a square section and is connected, by a sleeve with a square section hole through it, to the square section lower end of the case hardened En 32B upper portion of the drive spindle.

This upper portion of the spindle has a CP6 or B.S.241 phosphor bronze spiral gear keyed and spigoted on to its lower end and retained by a tab washer and nut on a thread just above the squared section. It is carried in a single $3\frac{1}{2}$in long × $\frac{3}{4}$ in bore flanged bush, of chilled-cast CP5 phosphor bronze, inserted from below into a boss in the crankcase. A cyanide hardened, En 32A thrust washer is interposed between the lower end of the bush and the gear. Oil is fed through a drilling from the main gallery to an annular groove round the bush and thence through radial holes to the bearing surface. Another annular groove is machined in the bore of the bush mid-way between its ends. This serves as a reservior to retain the lubricant while the engine is stationary. At the upper end of the spindle the diameter is increased to 1in and it is counterbored and slotted for the spigot and tongues of the distributor drive.

From the pump, the oil is delivered to a connection under the web that carries the centre main journal bearing. Thence it goes through the felt element of the Tecalemit full flow filter, mounted on the side of the cylinder block. The relief valve, which is incorporated in the filter, lifts at 50 lb/in^2. From the filter, the oil under pressure goes to the $\frac{11}{16}$in diameter main gallery on the right-hand side of the engine.

All the oil passages are of large diameter to ensure that even under the coldest conditions none of the bearings is starved of oil regardless of its distance from the pump. Wherever possible, the ends of the holes are countersunk. This is to remove the sharp brittle edges of the holes in the iron castings so that they cannot be broken away by the oil flow and damage the bearings. Each main bearing is served by a $\frac{3}{8}$in diameter hole, from the gallery, through which the oil passes to a groove round the bearing housing. This groove is machined eccentically relative to the axis of the bearing to clear the bearing cap bolts, which are offset to one side so that it is impossible to assemble them incorrectly.

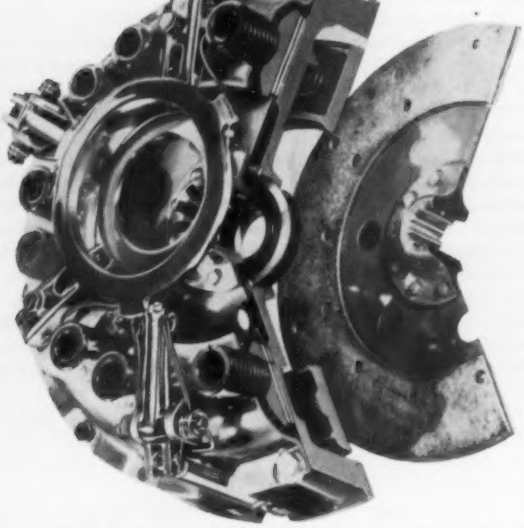
Four holes are drilled radially through each two-piece bearing shell, and the oil goes through these into a shallow groove on the bearing surface. From this groove, the oil passes not only to the main bearing surface, but also through a $\frac{9}{32}$in diameter hole drilled through the crankshaft to the adjacent crank pin. Because of the relatively heavy loading on the centre main bearing the drillings to the crank pins are taken only from the intermediate, front and rear journals.

As can be seen from the illustration showing the longitudinal section of the engine, the holes in the crankshaft are arranged in such a way that a $\frac{7}{16}$in diameter centrifuge sludge-trap is formed in the crank pin. Also, the feed to each big end bearing is through a $\frac{3}{16}$in diameter hole drilled at right angles to the plane containing the major axes of the adjacent pair of webs. Experimental work has shown that at high speeds the oil flow through the big ends is considerably reduced by drilling the journals in this manner in preference to drilling straight through from the main bearings to the outer faces of the crank pins. Excessive amounts of oil would otherwise be flung out of the bearing by centrifugal force, not only because the clearance at the outer face of the bearing is larger than at the sides, where the oil holes break out of the journal, but also because there is a tendency for the oil in the vertical drilling through the connecting rod to be flung into the small end bearing.

Each camshaft is served by a $\frac{5}{16}$in outside diameter × 20 S.W.G. pipe, which delivers the oil in through a hole drilled longitudinally from the rear face of the casting to join a vertical duct to the rear bearing. Thence the lubricant goes into the hollow shaft and through radial holes to the other bearings. An oil bath is formed in the tappet chamber on each side to receive the overflow from these bearings and to provide for the lubrication of the sliding faces of the cams and tappets. The tappet guides stand proud of the base of each chamber so that they are not flooded with oil, and the oil level is regulated by three ducts, one between each pair of valves, that form weirs over which the oil drains to the cell that houses the valve springs. Finally, the oil passes to the ends of the head and down through ducts to the timing case and sump.

Some of the oil draining from the front end of the head is splashed into a trough between the two arms on top of the spider, to lubricate the eccentric jockey sprocket. Oil from this trough passes through a vertical hole into an annular groove round the front end of the spindle of the eccentric. Then it goes through a radial hole into an axial one and thence through three diametrically drilled holes to the bearing.

The intermediate sprocket is lubricated in a similar way, but in this instance there are two holes to receive the oil splashed down from above. One is drilled from the top face of the front end of the block to a space between the block and the rear end of the spindle; from this space, the oil passes directly into the axial duct in the spindle. The other hole is drilled from the top of the front cover; it passes oil into an annular groove round the front end of the spindle and then through a radial hole to the axial one.



Borg and Beck combined power take-off and main drive clutches sectioned to show the general arrangement and main components

Dual Purpose Clutch

A Unit Comprising Two Clutches in Tandem, one for the Main Drive and the other for Power Take-off

A NEW Borg and Beck 11in diameter dual purpose clutch, manufactured by Automotive Products Ltd., of Leamington Spa, is now fitted to the Universal Tractor made by the Nuffield Organisation. This double clutch, which in effect is two units mounted in tandem, is bolted to the flywheel in the normal way. The unit nearest to the flywheel is used to transmit the main drive to the rear wheels, while the other is for the power take-off. There are two main advantages to this arrangement: one is compactness and the other is that both clutches are in a favourable position to transmit the drive.

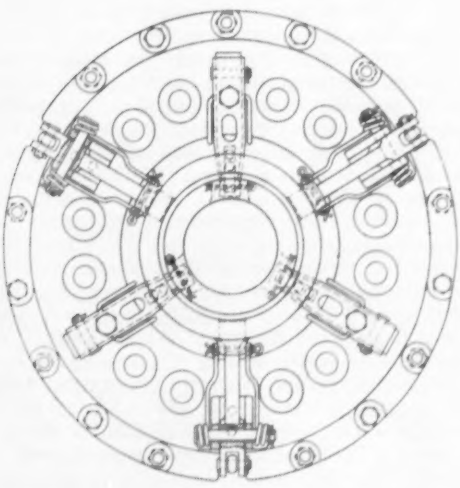
Both clutches are more or less conventional, so far as principle of operation is concerned. They are each actuated by an independent fork and a ball thrust bearing. The fork for the transmission clutch is actuated in the conventional manner by the clutch pedal, and the power take-off control is a hand lever to the near-side of the driver. Power is transmitted from the main drive clutch by a solid splined shaft to the primary shaft in the gearbox, while the power take-off clutch is connected by means of a hollow splined shaft to flanged dog-couplings and thence to a hollow pinion that drives a gear on an intermediate, power take-off shaft.

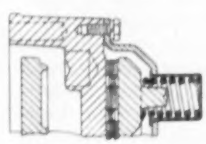
Power take-off clutch

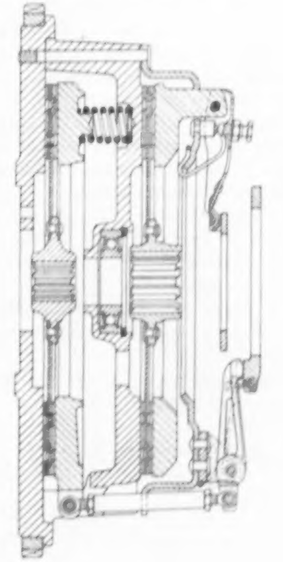
The principal components of the power take-off clutch are: a pressed steel cover, a pressure plate, twelve thrust springs carried in cups, and a driven plate. This driven plate carries a splined hub, to which a disc carrying the two friction facings is riveted. The power take-off cover is attached to the main drive cover by six set screws and spring washers.

Three lugs on the pressure plate extend through slots in the cover. These lugs transmit the drive from the cover to the pressure plate and also carry the pivots for the release levers. A short distance inboard of the pivot at the outer end of each release lever there is an adjustment screw and lock nut, while a leaf type retainer spring is riveted to the inner end of the lever. The forked lugs of the release plate

In the new Borg and Beck unit, the power take-off and main drive clutches are mounted in tandem on the rear face of the engine flywheel







fit over these inner ends and are retained by split pins passed through holes in the lugs in such a manner that the springs bear against the pins and force the ends of the levers into positive contact with the plate between the lugs. There are also three wire springs, one on each lever ; they are passed through holes in the levers, at points adjacent to the adjustment screws, and their ends are hooked under the edge of the hole punched in the centre of the housing. The function of these springs is to ensure that the adjustment screws are always in contact with their seats, which are riveted to the casing to act as the fulcrums for the levers.

Main drive clutch

A sturdy cover encloses the main drive clutch. Housed in the centre of the rear wall of this cover is a grease-packed ball bearing that carries the end of the power take-off shaft. The assembly inside the cover comprises a pressure plate, twelve thrust springs seating on heat insulation washers, and a driven plate. This plate is riveted to its splined hub, and has two friction facings.

Three turnbuckles connect the pressure plate to the outer ends of the release levers. Each of these levers is bushed to carry a headed pivot pin and is mounted in a yoke riveted to the rear face of the cover over the power take-off clutch. The connection between the release levers and the turnbuckles is effected by left-hand threaded eyebolts, screwed into the ends of the turnbuckles, and headed pins. Wire springs retain the inner tips of the release levers against their plate. These springs are secured by split pins to the inner ends of the levers and at the outer ends are wrapped round the ends of the pivot pins and bear against the yokes. Right-hand threaded eyebolts are screwed into the other ends of the turnbuckles, the connection to the pressure plate being made by headed pins passed through holes in the forked lugs on the periphery of the plate. These lugs project through slots in the cover to furnish the drive.

International Conference on Fatigue of Metals

A Conference at Which 70 Papers, All by Leading Experts on Fatigue, Will Be Presented

AN International Conference on Fatigue of Metals is being sponsored by the Institution of Mechanical Engineers in co-operation with the American Society of Mechanical Engineers. Meetings are to be held in London from the 10th to the 14th September, 1956, and in New York from the 28th to the 30th November, 1956. In London, the meetings are from 10 a.m. to 12.30 p.m. and 2.30 to 5 p.m.

It is also planned to arrange visits to centres at which research on fatigue of metals and metal components is being conducted. Persons registered to attend the Conference may take part in any number of these visits. Expenses will have to be paid by the registrants but the Institution will arrange transport and accommodation if required. It is expected that there will be about eight visits to places in England and Scotland from the 17th to the 21st September inclusive.

Those wishing to register for attendance at any or all of the technical sessions will be required to pay a registration fee of one guinea. An additional fee of one guinea will be payable by those wishing to take part in the visits. These fees are intended to cover administration costs. Advance copies of the Papers will be available by August 1st. They will cost £1 for the complete set and 3s. 6d. for the Papers of any one session. Bound volumes of the Proceedings will be on sale later. These will contain reports of the opening and closing sessions, the papers and discussions, and the Reporters' introductory notes, together with name and subject indexes.

With regard to registration, preliminary reply forms will be issued in May with *The Chartered Mechanical Engineers*. On receipt of these, the Institution will forward to applicants a detailed reply form, to be returned with the remitances. All registered members will receive a programme of the Conference.

The opening and closing sessions of the Conference will be held at the Central Hall, Westminster, and the other sessions will be in the Meeting Hall of the Institution of Mechanical Engineers. Owing to the large number of papers to be presented, it will not be possible for authors to give them in person. However, it is hoped that there will be sufficient time for the authors to make brief replies to the discussion. The papers will be presented in abstract by Reporters. About 30 minutes will be allowed for reporting in each session, so there will be about two hours for discussion and replies. The introductory address, on the other hand, will be delivered in person by Dr. H. J. Gough. Lists of speakers will be prepared before the meetings and any registered member may ask to be placed on the list. Speakers in discussions will be furnished with proofs of their comments before the Proceedings are compiled. At the follow-up Conference in New York, the Papers will be presented again for discussion.

Out of a total of 70 Papers, 40 are from Great Britain and Commonwealth, 20 from the United States and 10 from other countries. Session 1 on Monday morning, the 10th September, is the opening of the Conference by the President, Mr. T. A. Crowe, M.Sc., an outline of the arrangements, and an introductory address by Dr. H. J. Gough, C.B., M.B.E., F.R.S. (Past President). On Monday afternoon and Tuesday morning, sessions 2 and 3 on "Stress Distribution" will be held. These are followed on Tuesday afternoon by session 4 entitled "Temperature, Frequency and Environment". The following day, the morning session is on "Metallurgical Aspects of Fatigue" and the afternoon session is devoted to "Basic Studies". Session 7, on the morning of Thursday, the 13th September, is likely to be of special interest to automobile engineers, since it is entitled, "General Service, Automobiles and Specific Components." Session 8 in the afternoon is on "Air Frames and Engines," and session 9, on the following morning, deals with "Railways, Marine Engines and Welding." These last three sessions come under the general heading "Engineering and Industrial Significance of Fatigue." On the afternoon of Friday the 13th September, session 10 will comprise reviews by Reporters and a summary of the problems that have yet to be solved. The summing-up, to which 2½ hours will be devoted, will enable each reporter to speak for 15 minutes. Then the Conference will be closed.

WHITELEY POWER-ASSISTED STEERING

A Development with the Valves Incorporated in the Piston of the Jack

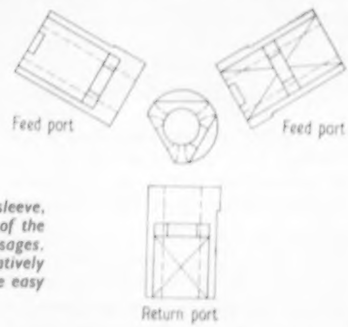
MENTION of the Whiteley power-assisted steering unit was made in the 1955 London Show Review issue of *Automobile Engineer.* Since then, further details have become available, and the general arrangement of the latest version of the unit is shown in the accompanying illustrations. This power-assisted steering system is based on a hydraulic jack. The end of the cylinder of the jack is attached by a ball joint to the vehicle structure, and the outer end of the tubular piston rod is screwed into a forging that carries a ball joint connection to the steering drag rod. Inside the piston rod is the valve rod, the outer end of which is connected by a ball joint to the steering drop arm. This ball joint is housed in the hollow forging on the end of the piston rod, but its movement, and therefore that of the valve rod, relative to the forging, is limited by stops, so that direct manual operation can be obtained in the event of failure of the hydraulic system. Direct operation is also required, of course, when the engine is not running, for example, if the vehicle is on tow.

Two hydraulic connections, one for the supply and the other for the return, are made by two flexible pipes to the forging that carries the drop arm and drag rod ball joint assemblies. Each of the two unions communicates with a separate annular groove in the periphery of a sleeve that is fixed in this forging. Pressure oil passes from the groove in the periphery, through a radial hole into an annular groove in the bore of the sleeve and thence through a radial hole into the hollow valve rod. The ends of the annular space in the bore of the sleeve are closed by U-section oil seals. Since the range of movement of the rod is small, the radial hole through which the oil passes can in no circumstances move past the oil seals and thus out of communication with the annular space. Because the sleeve does not move in the forging that carries the ball joint connections to the drop arm and drag rod, simple circular-section rubber rings in grooves on each side of the main oil passage are adequate to seal its outer periphery.

Returning oil passes from the annular space between the piston rod and valve rod, into the bore of the sleeve and annular groove round the periphery of the sleeve and thence to the return pipe. Since this is the low pressure side of the system, circular-section rubber rings are employed as seals between the end of the piston rod and a shoulder in the bore of the sleeve and also between the end of the sleeve and a shoulder in the forging that carries the assembly.

At the other end of the rod assembly, the piston is screwed on to its rod. It is hollow and houses the valve sleeve, in which the slide itself moves. There are three annular grooves round the slide. Radial holes are drilled from the bases of the two outer grooves to communicate with an axial hole in the slide. The valve rod is secured in the end of the slide in such a way that high pressure oil passing down the centre of the rod flows directly into the axial hole in the slide and thence through the radial holes to the two outer grooves.

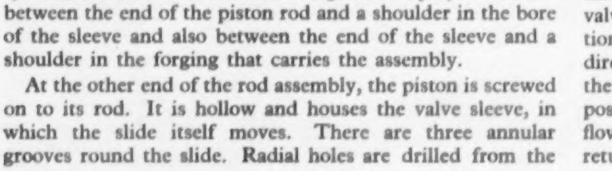
The central groove simply acts as a transfer passage to connect the port from one side or the other of the piston to the return system. There are three flats, 120 degrees apart, round the periphery of the valve sleeve, and the return oil passes from the cylinder along one of two of these flats, according to whether the slide has opened the port serving one side of the piston or the other, and thence through the

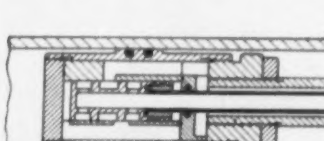


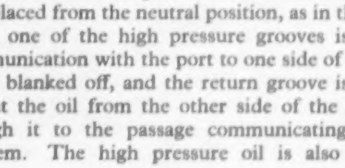
Views of the valve sleeve, showing the arrangement of the flats forming the oil passages. This component is of relatively simple shape and therefore easy to manufacture

open port, round the central groove in the slide valve and out through another port to the third flat. Thence the oil passes along this flat and into a space between the end of the slide valve housing and the end of the piston rod. From this space it flows between the inner and outer rods, for the piston and the valve respectively, to the other end of the unit and out through the flexible return pipe.

In the neutral position, the valve is centrally disposed between the ends of the sleeve ; at the same time, the lands between the pressure grooves and the central, return groove are directly in line with the ports that communicate with each end of the piston. Since these ports are larger than the lands, oil can flow directly from the outer grooves into the return groove, and thence along the third flat into the annular space between the piston rod and valve rod. If the valve is displaced from the neutral position, as in the illustration below, one of the high pressure grooves is placed in direct communication with the port to one side of the piston, the other is blanked off, and the return groove is in such a position that the oil from the other side of the piston can flow through it to the passage communicating with the return system. The high pressure oil is also placed in

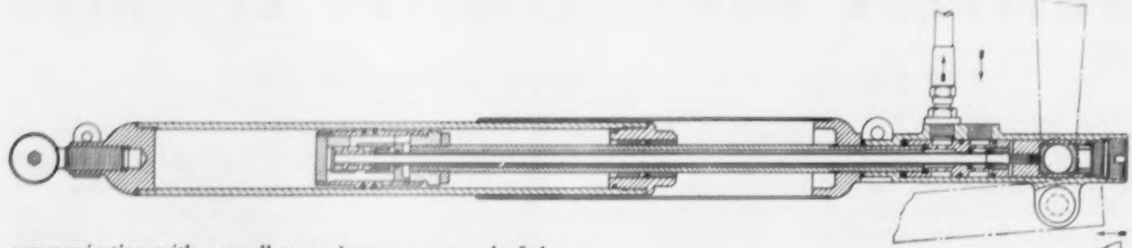


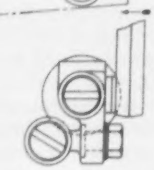




Left: Two views of the valve assembly, in the neutral position, showing the disposition of the grooves round the slide relative to the ports

Right: A view of the valve unit with the slide displaced from the neutral position. The arrows show the direction of oil flow





General arrangement of the Whiteley power-assisted steering unit. A sleeve shields the piston rod from contamination by abrasive matter

communication with a small space between one end of the valve and the end of its housing. This provides the necessary feel-back by tending to oppose the motion of the valve. Had the valve been moved in the opposite direction, the high pressure oil would have been placed in communication with the space at the other end of the valve ; in other words, still in opposition to the motion of the valve.

The main advantages claimed for the system are as follows. In the neutral position, there is no direct mechanical connection between the road wheels and the drop arm of the steering box. However, as soon as the road wheels are deflected a small amount due, for example, to their hitting a bump in the road, hydraulic pressure is immediately built up to resist the motion. This tends to damp out shocks that would otherwise be transmitted directly to the steering wheel. Another good feature is that there can be no tendency for the power jack to take charge and to continue to move the steering system after the driver has stopped turning the steering wheel. This is because any continuation of the motion of the jack would cause a reversal of the valve position, and therefore automatic correction. Since there are no springs in the valve unit, it is inherently free from vibration troubles. The piston rod is chromium plated and is protected from abrasive matter by a sleeve, mounted on the forging that carries the ball joints for the drop arm and drag link and extending over the end of the jack cylinder. Thus, the rate of wear of the piston rod, and the risk of damage to the oil seal by abrasive particles are negligible.

ALL-ALUMINIUM LORRY BODY

THE illustration below shows a special purpose body, built for T.I. Aluminium Limited entirely from "Timinium" alloys and fitted to a Leyland Octopus chassis. The lorry's duties are governed by the need for dealing with the Company's present expansion of business. Thus the design of the body had to make provision for such different loads as timber cases of aluminium sheet; foundry billets, up to 14 tons load; and scrap and swarf often containing heavy items.

The body is 24ft 6in long by 8ft wide and 3ft deep. Timinium alloy is used for the cross-bearers and the heavy-duty flooring is bolted directly on to them. Three 8ft sections form the sideboards. Each section consists of two panels hinged together. The top panel can be dropped and secured to the lower one and the two together lowered as one 18in unit.

The scrap and swarf load is segregated, prior to loading, into three classes. Each class must be kept apart, and two removable partitions of heavy-duty corrugated section accordingly divide the body into three 8ft compartments. Each partition slides down into place in channel guides, built into the intermediate pillars that retain the sideboards when they are erected. These four intermediate pillars, and the four corner pillars, are themselves detachable. The weight of the complete body is only 37 cwt, a very low figure for a payload of 14 tons.

Pneumatic Gauging

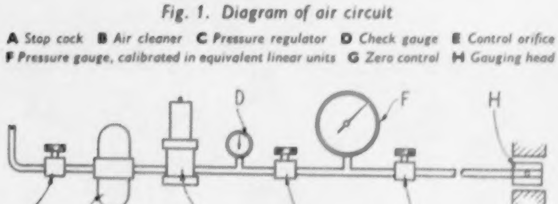
Fig. 2. Standard and miniature single-dial instruments have 6 in diameter and 4 in diameter dials respectively

Diverse Applications of the Mercer Dial-indicating, Back-pressure Type Instrument

ALTHOUGH pneumatic gauging has only a relatively short history—the patent literature referring to dimensional gauging by means of air or liquid pressure extends back less than 40 years—its present application is widespread. Numerous characteristic features contribute to the general adoption of the system in its several methods. It is uncommonly versatile in application and functions equally well on large or small work and for either internal or external dimensions. A single set of equipment can be used for a variety of different gauging operations by the provision of different gauging heads which are attached by means of a simple plug-in connector. Response is rapid and the indicating means, whether a dial or a column, can be arranged some distance from the gauging point. The height or depth of the gauging point in relation to the instrument has no influence in a high-pressure system, and the normal variations of shop temperature will not affect the accuracy of the reading. The lag is less than 1 sec for instrument-mounted gauges or immediately adjacent gauging fixtures, and rather more for a gauging head on a 4 ft flexible lead. Operation up to 15 ft is practical, though with a slower response, of course. In any case indication is exceptionally clear on relatively wide scales and does not call for close reading. Where multiple gauging operations are performed, indicating instruments are commonly grouped for rapid scanning. The magnification can be varied over a wide range in order to provide an open scale or a wide spacing of tolerance points.

Fig. 1. Diagram of air circuit

A Stop cock **B** Air cleaner **C** Pressure regulator **D** Check gauge **E** Control orifice **F** Pressure gauge, calibrated in equivalent linear units **G** Zero control **H** Gauging head



Despite the fact that an air gauge is suitable for measuring fine work in metrological laboratories, and for repetitive measurement of components to 0·00002 in on such items as parts of fuel injectors for diesel engines, it remains essentially simple as regards its pneumatic circuit and also in the construction of its relatively few component units. In theory there is no direct contact between gauge and work, though it may not be possible to avoid some guiding contact on non-vital areas of the gauge. As a consequence it is possible to gauge over highly polished or relatively soft surfaces without damage and the gauging elements are assured of long life. The flow of air keeps clear the conduits and nozzles in the gauge head and also tends to remove foreign matter from the immediately adjacent surfaces of the work.

The foregoing features, together with the fact that no special skill is required of the operative, make it particularly suitable for use in the workshop, either on the bench or directly on the machine, for checking work in progress. It is also readily adaptable for the automatic gauging of work in continuous production. On some fully mechanized transfer lines automatic air gauging is installed between

Fig. 3. Plug gauge for gudgeon pin bore in piston. Fitted to standard adaptor on instrument

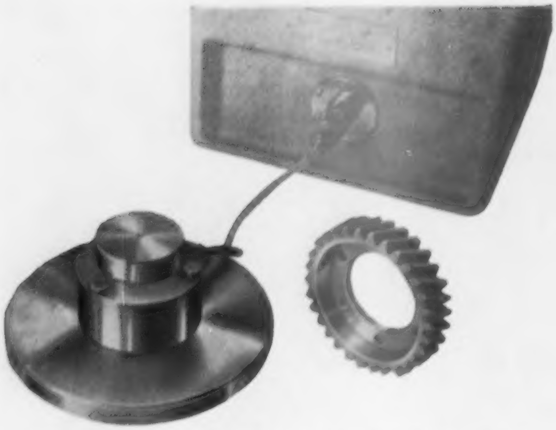


Fig. 4. Bench-type plug gauge for the shallow bore of a gear wheel

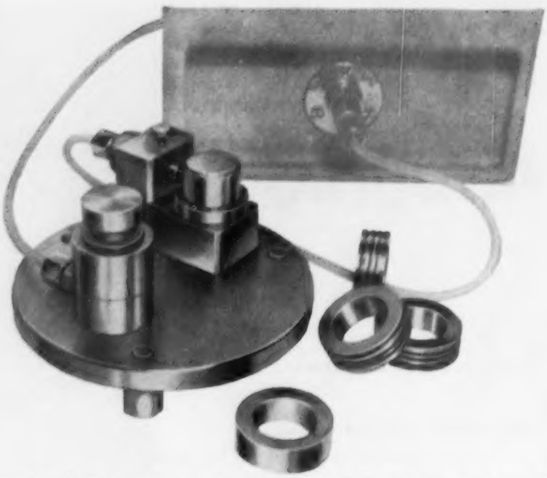


Fig. 5. Gauging unit for checking squareness and concentricity of the bore of an annular part

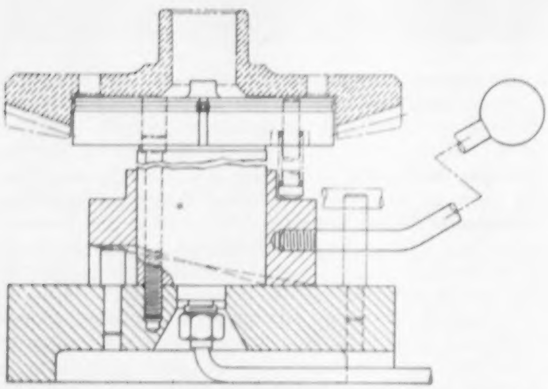


Fig. 6. Special fixture for the rapid checking of a shallow recessed bore in a crown wheel

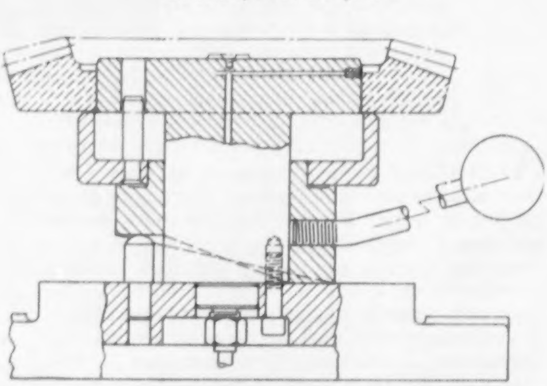


Fig. 7. Lowering and elevating fixture for gauging crown wheel bore

successive operations to check for conformance to tolerance, to warn, either audibly or visibly, when limits are approached as a consequence of tool wear, and to stop the machine in the event of faulty work being produced as a result of loss of adjustment or tool breakage.

Air gauging was introduced to meet the needs arising from mass production. Its adoption received a marked impetus during World War II and subsequently the development of high-rate flow production methods and the demand for still finer limits of tolerance have led to its more common use in the production line and also in multi-unit gauging stations to group products ready for selective assembly. For use on, or in conjunction with, transfer machines it has tended to become an essential component and in any approach to the goal of automation it would seem to be indispensable. Air gauging may be said to be able to meet many current requirements and also, it is anticipated, will provide a solution to the problems of automatic control in the immediately foreseeable future.

Various air systems

A number of different air circuits for pneumatic gauging have been developed and several have attained commercial application. All take compressed air from a shop line, pass it through a regulating valve and deliver it at a constant value to one or more metering orifices in the gauging head. The escape of air from these orifices is influenced by the proximity of the work being gauged and the effect, in the form of variation of back pressure or of flow rate, is indicated by appropriate equipment on a suitably calibrated scale.

Apart from variants and combinations, most systems will be found in one of two main groups; the original back-pressure type, most common in Britain and in Europe and the flow type which is widely used in America. The back-pressure systems may conveniently be divided into two sub-types; the high-pressure system indicating on a Bourdon-tube pattern dial gauge and the low-pressure system in which pressure variation is indicated by a water column.

Irrespective of type or air circuit, an air gauge is not a measuring instrument but fundamentally is a comparator. The instrument is calibrated against masters and indicates plus and minus deviations in the work from the dimensions of the masters. This characteristic is actually of great advantage since the geometrical features of the work and also of the wearable surfaces of the gauging head affect the value of the air discharge coefficient and, consequently, the gauge indication. The use of masters also permits the replacement of gauging elements, or even the substitution of completely different gauging heads, without the necessity of re-graduating the scale of the intrument.

The Mercer air gauge

Mercer instruments are of the back-pressure type with dial indication. Air is supplied from the shop line at a pressure of from 60 lb/in² to 120 lb/in² and through a special air purifier to a precision, diaphragm type pressure

regulator. From the downstream side of this unit the air at a constant pressure of 40 lb/in^2 passes to a check pressure gauge, and to a variable control orifice to permit flow regulation to suit different gauging heads within the range of the instrument. Thereafter, the air stream passes to a sensitive pressure gauge, a variable bleed to atmosphere (for zeroing the instrument) and finally, by way of a flexible conduit, to the gauging head. Components and controls are housed in a cast light alloy casing having a commendably smooth exterior. The indicating dial is arranged in a plane inclined to the vertical for convenient reading and the conduit to the gauging element is attached by a plug-in adaptor at the front of the instrument and secured by a bayonet latch. A sunk carrying handle is provided at the top of the casing. Overall dimensions of the standard instrument are height 11¾ in, width 9 in and depth 10½ in. The weight is approximately 30 lb.

An instrument of reduced size, shown alongside a standard unit in Fig. 2, is available for direct installation on machine tools, for wall mounting, for use on inspection benches and other locations where close reading is possible or where space is at a premium. It has a 4 in diameter dial, instead of the normal 6 in diameter dial, and a different layout of the controls, but otherwise resembles the standard instrument. A twin dial unit is also in regular production for simultaneously checking two dimensions on such work as two-diameter bores, spaced diameters on tapers, or the extremities of blind bores. This instrument is 16¾ in wide and weighs about 44 lb. Grouped instruments for multi-dimensional checking are built up either into a complete gauging unit or as part of a gauging station, to meet specific requirements. Such assemblies can be arranged to link with coloured light systems or with other visual or audible warning of out-of-tolerance or reject components.

Standard dials have a 270 deg scale and are of the balanced type with a centre zero. They are available for ranges of 0·002 in and 0·004 in, both reading in increments of 0·0001 in and for a range of 0·050 mm reading in 0·001 mm. Dials can, of course, be specially scaled to meet specific requirements. The instrument may be graduated with the zero disposed to either the plus or minus side, with coloured bands or segments, or other variations peculiar to mass production systems or where unskilled labour is used. A special 180 deg high magnification scale is graduated for direct reading to 0·00005 in.

Pneumatic gauging elements

The actual gauging elements carrying the metering nozzles are designed to suit the component to be gauged and, consequently, may be of widely differing size and shape and may be arranged for either manual or mechanical application. Despite this variety, however, elements can be classified into three general types. In the first, an air jet is applied directly to the work which is not in contact with the gauging head at the point of measurement. Gauging heads in the second group embody a mechanical component to contact the work at the measurement point and indirectly influence the air jet. The third group is more limited in its application and is generally used to determine the cross-sectional area of a bore or an orifice rather than its dimensions or shape. The bore of the work constitutes the air escape area and should this area be beyond the capacity of the instrument it may be reduced by means of a suitable imperforate restrictor.

Plug Gauges

The principle of the direct air gauge is that the air flow, and consequently the back-pressure, is approximately proportional to the escape area. This annular area is determined by the circumference of the nozzle bore multiplied by the clearance between the nozzle end face and the work. In multi-nozzle gauging heads it is essential that nozzle dimensions are balanced in order that displacement of the work will result in only a negligible change of indicated values. It will be appreciated that as the work is displaced from one nozzle the escape area is almost exactly compensated by the closer approach of the work to a diametrically opposite nozzle.

Pneumatic plug gauges, probably the simplest and the most widely used of this group of gauges, are frequently designated

Fig. 8. Gauging cylinder bores on the machine table with a hand type plug gauge

Fig. 9. Self-locating plug gauge for splined bores

Fig. 10. Two-jet plug for checking the root diameter of splined bores

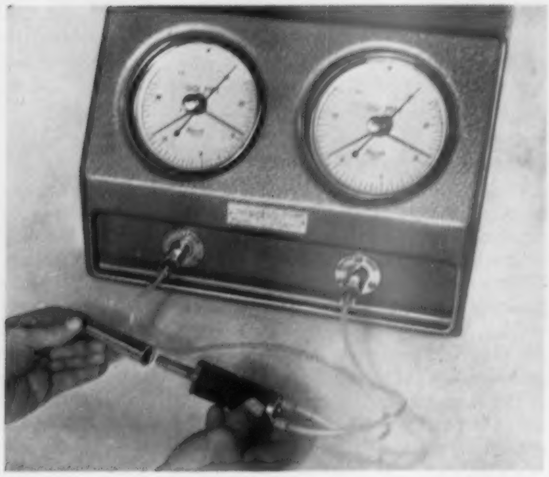


Fig. 11. Plug gauge for simultaneously checking two diameters of a taper bore

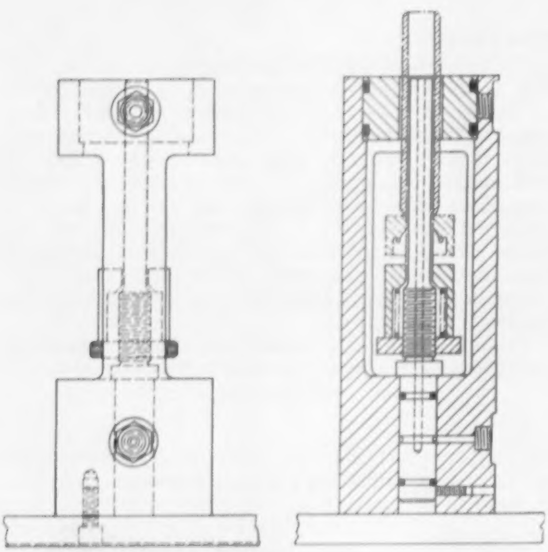


Fig. 12. Gauging fixture for the bore and outside diameter of a valve guide

Fig. 13. Bench type, direct-jet gauge for thin-walled cylindrical parts

"gauging mandrels" or "gauging spindles". Fig. 3 shows such a gauge, mounted directly on the instrument and with its diametrically opposite nozzles lying in a horizontal plane, used for checking the diameter of the gudgeon bore in a diesel engine piston. Manufactured to adequate standards of precision, the mandrel ensures that the axes of the gauge and the work are approximately coincident and that the jets are truly radial in a plane normal to the axis.

When required for checking a true diameter, two diametrically opposite nozzles are used, but three or more nozzles may be provided to obtain average values of the diameter. Special mandrels are available for determining other factors in a bore, such as straightness, lobing or bell-mouth, and gauging fixtures are produced to specific requirements for checking squareness of a face with the axis of a bore, bowing of a face, or concentricity of a bore with an external diameter. Fig. 4 shows typical plug-gauging units for the shallow bore of a helical gear wheel, while Fig. 5 shows a specially built unit for checking the squareness and concentricity of an annular component.

Special fixtures for the rapid gauging by unskilled labour of a shallow recess and a bore in transmission crown wheels are shown in the drawings Figs. 6 and 7. On each of these the component is merely laid horizontally on supporting elements, approximately centred, and then lowered to traverse the bore over the gauge plug by partially rotating a helical face cam member bearing on the cylindrical support column of the gauge. After gauging, the return of the cam member to its original position raises the component clear of the gauge plug to facilitate unloading.

For checking work in continuous production, or for gauging between operations, it is generally more economical to take the instrument to the place of work rather than to bring the work to an inspection bench. A typical example is illustrated in Fig. 8. There an air gauge set up alongside the machine is used for the immediate checking of the bores of a four-cylinder engine block. The diameter of these bores is held to limits of +0·0004 in and —0·0006 in.

Splined bores cannot, of course, be checked by means of conventional plug gauges. Special gauging heads, however, are manufactured for the purpose. For measuring the bore, the plug is provided with two diametrically opposite ball locators which are entered into spaces between the splines and thus bring the two air nozzles, arranged at 90 deg to the balls, into correct radial position over the crests of splines to check the bore diameter. A mandrel of different pattern is required for gauging the root diameter. This is formed with, say, six splines which guide and centre it in the component. The air jets are mounted, diametrically opposite, in two of these splines. Gauges for checking the width of individual splines and the width of the spaces between the splines can be made for dimensions down to a minimum of 0·125 in.

A twin-dial instrument is used for the gauging of taper bores. The special gauging mandrel has axially spaced pairs of air nozzles, each on a separate air circuit. Thus, when the mandrel is inserted in the bore the two diameters are simultaneously indicated on the instrument dials. The illustration, Fig. 11, shows the set-up for routine checking of the bores of taper drill sockets.

Plug gauges can be manufactured to check all reasonable bore diameters down to a minimum of 0·0937 in. Every gauge is supplied with two master setting rings to enable the instrument to be set up or checked over the working range of the specific dimensional limits. These rings are nominally made to the upper and lower limits of the part to be gauged. The actual sizes of the rings, owing to manufacturing tolerances, will be within a few hundred-thousandths of an inch of the designated limits. Each ring is precisely measured and its actual dimension is engraved on its side.

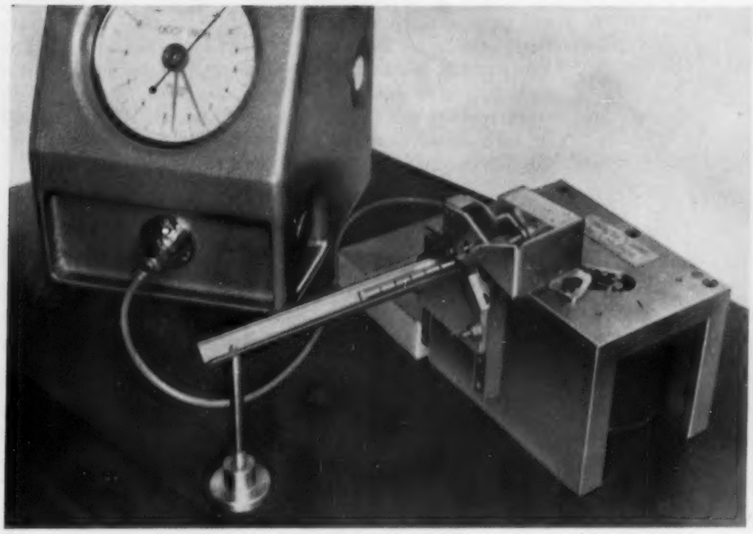


Fig. 14. Mechanized fixture for batch-gauging rollers of fourteen different diameters

Fig. 15. Direct-jet fixture for the continuous gauging of precision strip material

Fig. 16. Mechanical-contact type gap gauge

Fig. 17. Mechanical-contact hand gauge for use in the workshop

Ring gauges

The converse of the plug gauge is the ring gauge for checking the outside diameter of cylindrical parts. Like the plug gauges, they are provided with two diametrically opposed air nozzles for measuring a true diameter or with three or more nozzles to determine an average diameter or lobing. Usually such gauges are mounted on a support having a substantial base and the work is introduced horizontally. Each ring gauge is supplied with two master setting plugs for checking the adjustment of the instrument.

Ring and plug gauges are sometimes used in combination fixtures for the simultaneous checking of external and internal diameters. Such a fixture for measuring the entire length of a valve guide is shown in Fig. 12. In what may be termed a lantern body member, the air mandrel for the bore is mounted in the base and the ring gauge for the external diameter in the head. Slidable over the mandrel is a stop member supported by a helical spring from a screwed ring adjustable for height on the stem of the mandrel. The operator feeds the component through the ring gauge and over the mandrel, depressing the stop against the spring until the full length of the component is within the ring gauge. On release, the spring raises the component about one inch so that the end protrudes to facilitate unloading.

Direct-jet gap gauges

Fixed gap, caliper gauges are produced in a variety of patterns for hand or bench use and also as measuring components for more elaborate gauging fixtures. The jaws are usually faced with hard metal and a back stop is provided to facilitate location on the work. Hand gauges can be used for work in progress on machine tools while the mounted bench gauges are specially useful for the inspection of thin-walled or other relatively delicate parts without the risk of distortion.

Direct-jet gauging fixtures for the external measurement of parts are particularly suitable for the rapid routine inspection by unskilled labour of parts in mass or continuous production and can be developed for automatic gauging systems. Opposed air nozzles are mounted in relation to a chute, track or conveyor belt on which the work is passed through either manually or mechanically. An example is shown in Fig. 14 of a mechanized fixture for gauging the diameter of cylindrical rollers used in fuel injection equip-

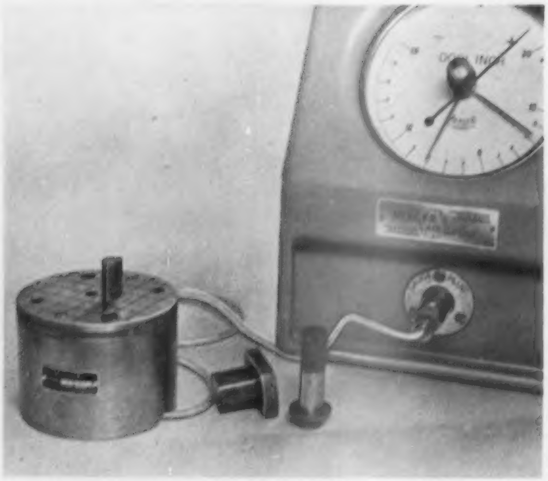


Fig. 18. Fixture for gauging the depth of gear pump bodies

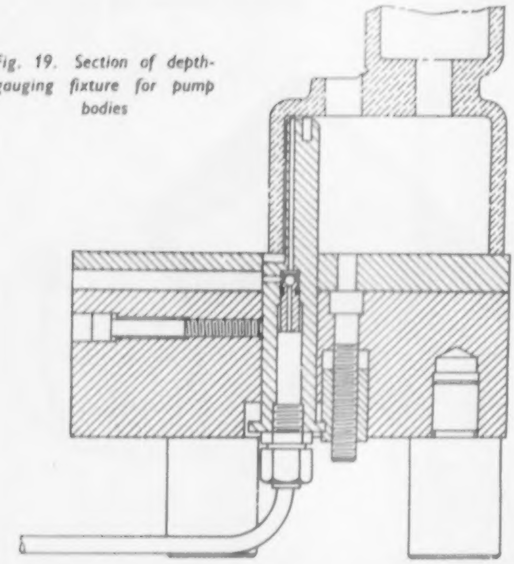


Fig. 19. Section of depth-gauging fixture for pump bodies

ment. The rollers are loaded into a chute and slide by gravity to a feed roller faced with a resilient material. This roller is driven by a fractional h.p. motor mounted on the fixture and both its pressure and the angle in relation to axis of the work in the chute can be adjusted to vary the rate at which the work is fed through the gauging position. Rollers of fourteen different sizes ranging from 4·5 to 10·0 mm diameter are gauged with this equipment. The work is batched and the fourteen direct-jet gap gauges to accommodate the different components are interchangeable on the fixture.

An interesting application of the direct-jet method occurs in the continuous gauging of precision strip material. The special equipment for this purpose, developed in conjunction with Glacier Metal Co. Ltd. of Alperton and shown in Fig. 15, can check strip up to 8 in in width and down to 0·004 in in thickness. To facilitate the perpendicular setting of the heads, the yoke is pivotally mounted on the base structure and is stayed in its adjusted position to obviate any possible vibratory movement. From the pivot point the air lead from the instrument is branched and separate flexible leads are taken to upper and lower air nozzles. The lower nozzle is fixed in the yoke arm but the upper one is mounted in a micrometer head to allow adjustment to accommodate strip of different thicknesses. Strip material to be checked is reeled between the gauging heads under appropriate tension to ensure flatness and straightness.

Mechanical-contact air gauges

In many instances mechanical-contact gauges, in which the relative movement of opposed jaw surfaces is measured pneumatically, can offer advantages over the direct-jet type of gauge. They occupy a minimum of space, can be adapted to provide special jaw forms for awkwardly located or closely confined work, and can measure close up to the corner of a shouldered workpiece. Since such gauges are readily adjustable over a range of $\pm 0{\cdot}015$ in from the mean dimensional capacity, wear on the jaws can easily be accommodated. It is common practice, however, to face the jaws with hard steel, hard chrome, or tungsten carbide. The typical gauge in Fig. 16 has a fixed lower jaw and a movable upper jaw.

Plug gauges can also be of the mechanical-contact type. In this form they are specially suitable for workshop use, routine inspection by unskilled labour, or automatic gauging in the machine line.

Mechanical-contact gauging devices are made for a wide variety of special applications, such as the depth of blind bores or irregular orifices. Of considerable interest is the fixture for gauging the critical depth of a gear pump body. The component is placed on the striated table and tracked over the upstanding gauging head, so that the end wall closing the bore is traversed to check flatness. One side of the head is machined away so that the contacting end of the plunger can closely approach the corner of the bore. In the illustration, Fig. 18, the fixture is shown connected to the gauge instrument and alongside is a setting master and an alternative gauging unit. Constructionally, it resembles the fixture in the sectional drawing Fig. 19. From this it will be seen that the slender carbide-tipped contact plunger controls the lift of a ball that obturates the air nozzle. In the top of the gauging head, faced to 0·002 in below the gauging

Fig. 20. Multi-dial instrument for checking camshaft journals

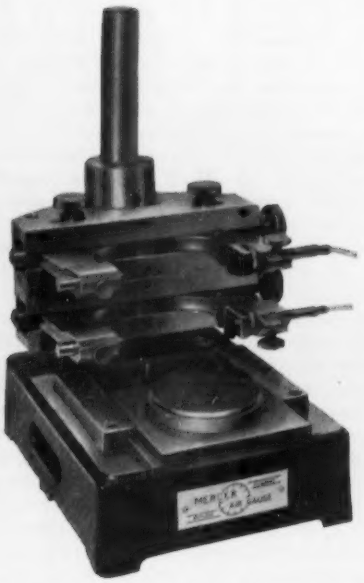


Fig. 21. Pistons of six different diameters are checked at two levels on this adjustable fixture

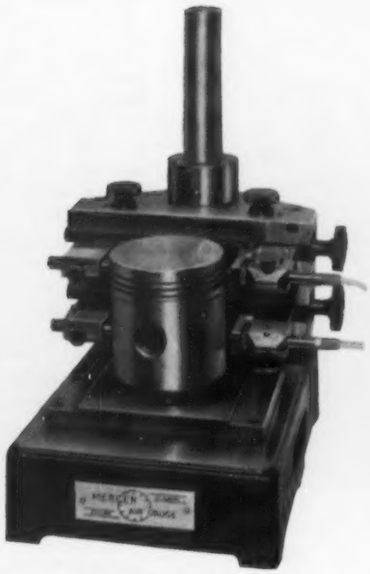


Fig. 22. The piston is slid into the gauging position between solid contacts and microjet units

Fig. 24. The M.I/1 precision comparator has a guaranteed repetitive accuracy of 0·00002 in

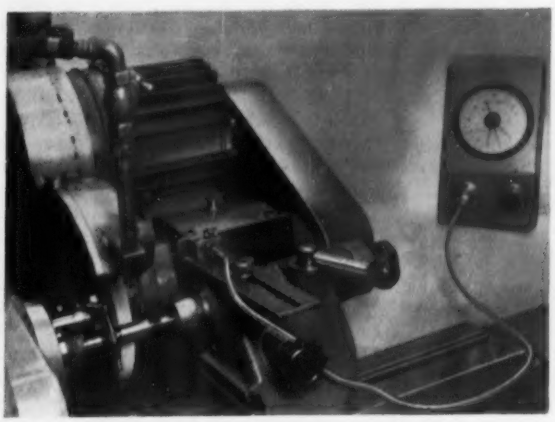


Fig. 23. Microjet used for fine control of in-feed on grinding machine

height, is a hard metal insert which prevents the plunger or the air nozzle sustaining damage in the event of an undersized component being forced down over the head. The height of the gauging head above the table is adjustable by a socket screw and sleeve nut device, laterally engaging a flange at the base of the gauging member.

Another application is the special fixture, Fig. 20, for gauging the three journals of the camshaft of a four-cylinder engine. This embodies three mechanical-contact gap gauges, similar to that shown in Fig. 16, used in conjunction with a typical multi-dial instrument.

Microjet plunger units

These small, cylindrical, mechanical-contact type gauging units are produced for incorporation in virtually any type of gauging fixture, for machine control applications, and as measuring elements for comparators. The carbide-tipped plunger operates an obturating device which can be arranged to produce an amplification factor similar to, or greater or less than that obtained with a direct air jet. The amplification factor of a particular microjet unit is not adjustable.

Standard ranges are manufactured to different diameters and in long and short versions. To special requirements they can be made down to 0·3125 in diameter and 1·25 in long. There are two main types; normal acting and reverse acting. Depression of the plunger in the normal type, intended for external measurement, produces a pressure drop in the air system. The converse applies in the case of the reverse type, used for internal measurement.

Microjet units are shown mounted on the right-hand arms of the fixture for gauging land and skirt diameters of pistons, Figs. 21 and 22. The piston is located on a spigot plate slidable in guides on the fixture base and is then pushed forward to a stop to bring it into the gauging position. This

Fig. 25. Workshop air comparator fitted with microjet measuring unit

Fig. 26. Multiple dial-gauging set-up for flanged wheel hubs

Air Comparators

These instruments, designed for workshop, inspection department and metrology department use, also embody a mechanical-contact microjet as the measuring unit. Two models are produced; W.S/1 expressly for gauging alongside the machine and for routine production checking and M.I/1 to meet the more exacting requirements of tool, inspection, and metrological departments. The M.I/1 model has a heavy base, a shrunk-in column of relatively large diameter, and a substantial arm to secure the necessary rigidity and stability to ensure consistent accuracy of measurement. Coarse and fine adjustment of the height of the measuring head is provided; the fine adjustment being on the column for W.S/1 and on the microjet mounting for M.I/1. These comparators are usually set up by means of slip gauges to the required tolerance. For normal shop use it is customary to supply setting masters for high and low limits. These may take the form of specially made slip gauges or of masters similar in shape to the component being measured. A repetitive accuracy of $\pm 0{\cdot}00001$ in is readily achieved. Platens of various types are produced to meet different requirements. That shown on the M.I/1 comparator in Fig 24 is reversible; the two lapped surfaces being respectively flat and striated. The base can be furnished with bushed holes for the attachment of auxiliary equipment.

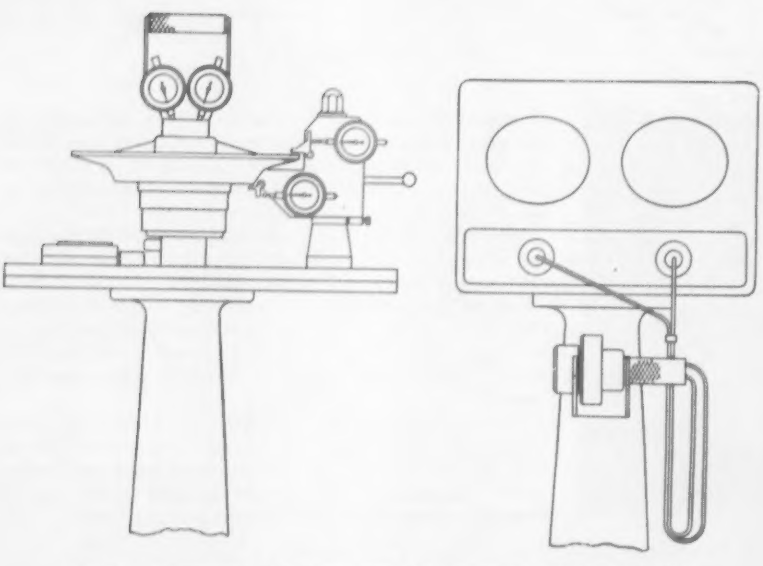


Fig. 27. Arrangement of gauging station for commercial vehicle wheel hubs

fixture is fully adjustable to accommodate pistons of six different diameters. Measurements are indicated on a twin dial instrument.

An instance of the unobtrusive manner in which a microjet unit can be fitted to a machine tool is shown in Fig. 23. This grinding machine is used for taking off fine diameters to finish work to very close tolerances. The microjet unit is mounted on a bracket secured adjustably to the tailstock on the work table and makes contact with a precision ground plate fitted to the front of the grinding head. A small standard instrument having a balanced scale range of 0·002 in, in increments of 0·0001 in is used. As the finishing cuts are taken a continuous indication of work diameter is given on the instrument and a close and sensitive control of in-feed of the wheel can be maintained. In the example shown, the work in hand was limited at $\pm 0{\cdot}00002$ in and no difficulty was experienced in holding work to the tolerance.

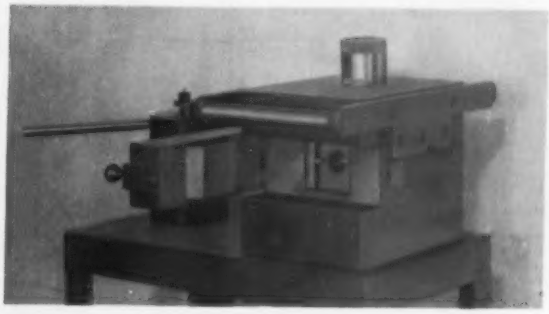
Combination gauging systems

While pneumatic gauging methods can be applied to most classes of work and are being more generally adopted, they do not in practice supersede other methods, either mechanical or electrical. Rather they offer the production engineer an additional and markedly different approach to gauging and inspection problems. Many factors such as the specific characteristics of the work, shape, size, accessibility, production rate, and the standard of precision specified, will influence the choice of method. The decision may also be affected according to whether gauging is to be performed on the machine, in the shop, or in an inspection department ; whether gauging is for conformance to tolerance or for selective grading; and whether skilled or unskilled labour is to be employed.

The makers of the air gauging instruments illustrated in the foregoing pages, Thomas Mercer Ltd., Eywood Road, St. Albans, Hertfordshire, have for long manufactured a comprehensive range of mechanical dial-gauging equipment. In numerous instances mechanical and pneumatic gauges of Mercer manufacture supplement each other in the same plant, the same shop, or even on the same component. Figs. 26 and 27 relate to a recently supplied gauging station for commercial vehicle front wheel hubs. Two bores are gauged simultaneously by a two-diameter air plug gauge and a pedestal-mounted, twin-dial instrument. The scales are provided with coloured sectors which define the tolerances for easy and rapid scanning. After the air gauging, the component is placed on the revolvable locator of a closely adjacent, pedestal-mounted fixture. On this are checked the squareness of two abutment faces, the concentricity of two bearing diameters, and the squareness of two large diameter flanges. All these checks are made with mechanical dial gauges.

Investigation of Cutting Tool Life

The Use of Radio-Active Tracer Elements to Determine Factors that Affect the Rate of Wear of Cutting Tools



The tool tips are stored on a mandril inserted from above into a lead chamber. In this illustration, the door of the chamber, through which the tool holder is inserted to remove the tip, is shown open

BECAUSE of the current trend towards the employment of more and more complicated and expensive machine tools, idle time is becoming increasingly important as a factor affecting production costs. As a result, most manufacturers are constantly seeking means of increasing cutting tool life. The benefits of such increases are as follows. A larger ratio of production time to idle time of the machine tool is obtained. Replacement costs are less, so far as cutting tools are concerned, and less time is wasted in setting up and sharpening tools. The finish of the components is generally of a higher standard, and the life of the cutting fluid and its contamination rate is reduced.

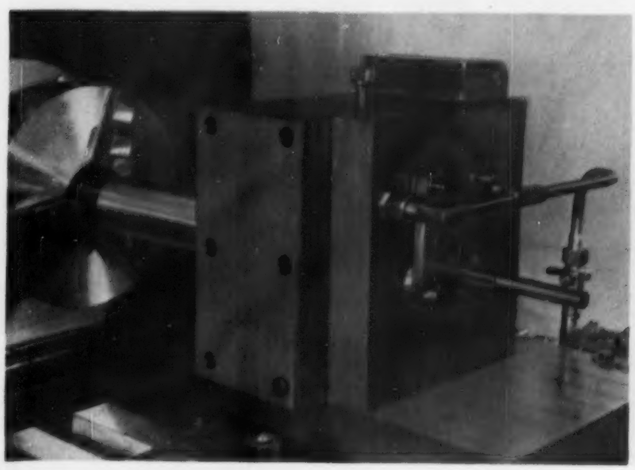
Certain standard tests to evaluate cutting tool life, machineability of metals and effectiveness of coolants have been established for a long time. They involve drilling and turning under production conditions, and generally are lengthy and expensive since, in many instances, they have to be run till the cutting tool fails. Moreover, because of the long time and large amount of material needed for such tests, not only is the expense of carrying them out high, but also there is considerable likelihood of the introduction of variables that may lead to inconsistent or erroneous results.

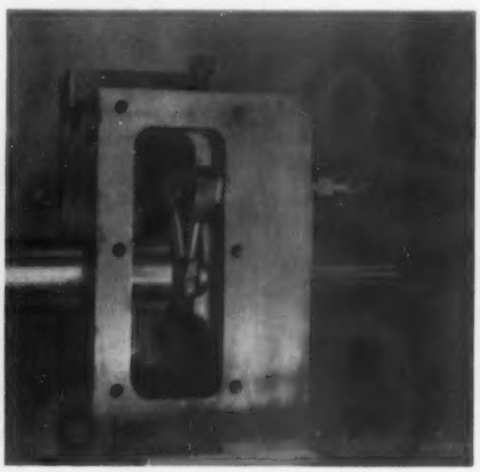
The new tests

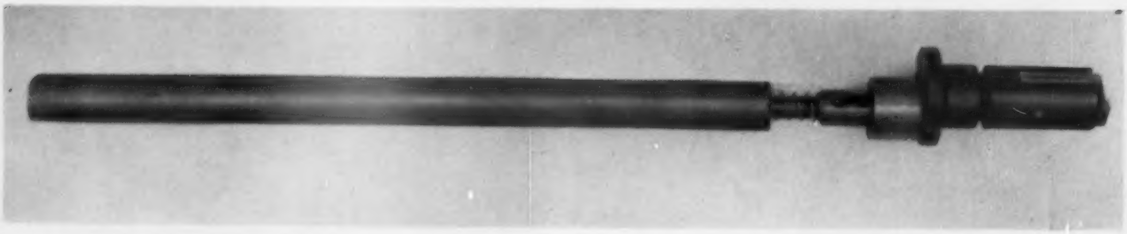
Alexander Duckham and Co. Ltd. claim to have the first laboratory in Great Britain for using radio-active tools for research into tool life, cutting fluids and machinability of metals. The basic principle of the tests is as follows. A radio-active cutting tool in employed; as it wears, radio-active particles are transferred to the turnings and the cutting coolant. It has been established that 95 per cent of the tool wear products are always embedded in the chips, and the amount of radio-activity so transferred, therefore, bears a direct relationship to the wear on the tool., The amount of radio active material transferred can be determined by carefully drying and weighing the chips and exposing them to a scintillating counter, which records radio-activity as so many pulses per second on a scaling unit. This method of testing has the advantage that it is simple, rapid, and the amount of metal of the work piece consumed is only about a quarter of a pound. Moreover, the results are accurate and can be repeated.

The first stage in the development of this method was to select cutting tools that can be rendered radio-active by irradiation in a nuclear reactor to produce suitable radio isotopes. Earlier workers established that selected tungsten carbides treated in this way give tracer radio isotopes cobalt 60 and tungsten 185, which have adequate energy and a half-life long enough for the cutting tool to be satisfactory for studies over a reasonable period of time. The half-life is defined as the time during which an isotope loses 50 per cent of its radio-activity.

To protect the operators from radiation, the cutting tool and the end of the workpiece are enclosed in a thick steel chamber. On the left, the chamber is shown closed, ready for operation, and on the right it is open to show the two cutting fluid jets above the tool tip and holder







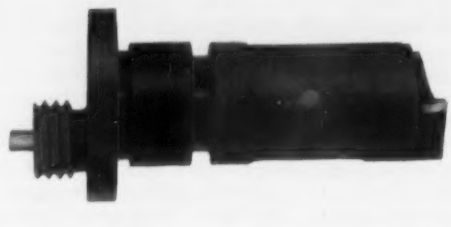
A long handle is attached to the tool holder to reduce the risk of exposure of the operators to radio-activity emitted from the tip. To actuate the push rod that releases the tool tip, the handle slides in the adaptor that is mounted on its end and screwed on to the tool holder

For the experimental work, Wimet X.8 tungsten carbide was selected. This material has the following chemical analysis: tungsten carbide 77 per cent, cobalt 8 per cent, titanium carbide 15 per cent. When subjected to neutron bombardment in a nuclear reactor for approximately one week, this material gives tracer radio-active isotopes of cobalt 60 and tungsten 185 with properties that were regarded as satisfactory for the initial studies. Cobalt 60 has a half-life of 5·2 years and emits beta and gamma radiation, while tungsten 185 has a half-life of 73 days and emits only beta radiations.

Tools

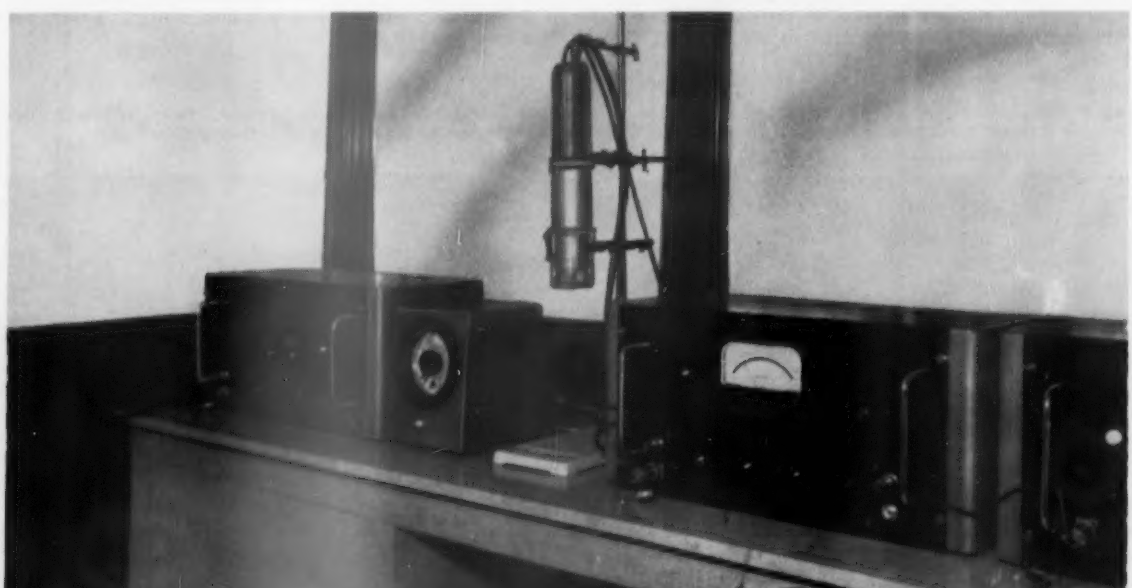
The tools used are approximately $\frac{1}{4}$ in. square by $\frac{3}{32}$ in. thick and weigh about 15 grammes. Each is finish ground to shape and marked for identification and has two cutting edges. The tools are sent to Harwell for irradiation and are hotted up until their total beta and gamma activity is approximately 15 millicuries per gramme of tool tip. One curie is defined as $3{\cdot}7 \times 10^{10}$ disintegrations per second. Of the 15 millicuries, 10 are of beta radiations and 5 are of gamma radiations. For the purpose of tool wear studies, gamma radiations only are used, because beta radiations have only slight penetration power and do not record well because of chip piling. Gamma rays, on the other hand, have good penetrating powers, since they consist of high energy rays of short wavelength, and they also have good recording properties. Cutting tools activated in this way are estimated to give about 80 minutes of cutting time per tool edge.

An enlarged view of the tool holder, showing a tip clamped between the jaws at its right-hand end



It is only necessary to cut for a duration of 6-10 seconds to give gamma radiation counts of 3-5 per minute on the

The beaker of dried and weighed radio-active turnings is exposed to the head of the scintillating counter, and the radio-activity of the chips is recorded as so many pulses per second on the scaling unit. The beaker and head are near the centre of this illustration



The cutting chamber is mounted on the bed of a Swift 8V.3 lathe powered by a 15 h.p. motor. Rigidity is the most important requirement for machine tools for tests of this kind, if inconsistent results are to be avoided

scintillator. Thus, once the machine has been set up, about 500 tests can be run off. It is normal practice to repeat each test five or six times to obtain an average of the results. In each instance, the results are checked against a standard. The tool wear is expressed as counts per minute per gramme of chips. It is necessary, of course, to deduct from this count the background radio-activity reading due to radiation naturally present in the atmosphere and also due to scatter from the radio-active material in the laboratory.

Safety precautions

In these early experiments, elaborate precautions have been taken in respect of the danger of nuclear radiation, although the activity of 15 millicuries per gramme is not high. The section of the mechanical test laboratory devoted to radio-active tests is separated from the remainder by metal and glass partitions, and is equipped with plastics covered benches and floors. These materials are impervious, so they can be cleaned readily and can be decontaminated quickly, should they come into contact with radio-active substances. Protective clothing and shoes are worn by all personnel working in this laboratory. A carefully designed and constructed decontamination zone has been established, through which all personnel must pass before leaving the danger area.

All personnel working in the laboratory are subjected to a medical check every five weeks, and stringent measures to ensure safety are adopted. Each operator is supplied with a personal dosemeter, which indicates the radiation risks that he is running and enables him to see at any time what he can or cannot do without exposing himself to harmful quantities of radiation. A log is kept of the degree of exposure of each operator, to ensure that he is not subjected to a dosage rate of more than 0·3 roentgens per week, which is the maximum permissible.

The radio-active cutting tools are stored in a specially constructed lead chamber, in the centre of which is a mandril to hold four tool tips. This mandril can be rotated so that the tool holder can select any one of the four tips. The tool holder is inserted from a safe distance and a spring release cam is operated to engage the tool tip. Then the tool is withdrawn from the chamber, and the lid closed.

Apparatus and method

In the initial experiments, tubular steel work pieces were employed. The material was a 60 ton chromium molybdenum steel in the annealed condition. Cuts were taken normal to the major axis of the tube so that the operation could be carried out in a steel chamber, which surrounds the tubular work piece, held in the chuck of the lathe, and screens the operators from radiation. Tubing was also chosen for the work piece because it avoids problems with regard to surface condition, and also a constant cutting speed in terms of ft/min can be obtained readily.

The cutting chamber, the walls of which are 1 in thick, is mounted on the bed of the lathe. It is designed so that access for changing the tools is easy and also so that it can be cleaned readily. A cutting fluid circulation system is incorporated in the chamber. It supplies cutting fluid through two jets, one on each side of the tool. The fluid drains into the base of the chamber, is collected into a reservoir and then recirculated over the work piece and tool. All the turnings are collected in a small perforated tray.

Cutting proceeds until approximately 1¾ oz, 50 grammes, of chips are produced. This has been found enough to give an adequate radio-active count. In the tests carried out so far, the time required for machining this amount of metal is 10 sec. The machine setting for speed and feed can be varied according to the type of study. Speeds of 200-800 ft/min are possible with feeds from 0·003-0·15 in per cut. When the cutting operation is completed, the perforated tray containing the chips is taken from the chamber. The chips are then placed in an aluminium or stainless steel tray, taken to the measuring laboratory and washed. Water and methylated spirits are the washing agents for a soluble oil coolant. When a neat oil coolant has been employed, solvent naphtha is used for washing. Finally, the chips are dried, weighed and exposed to the scintillating counter for measurement.

Alexander Duckham and Company express their thanks and appreciation to the Directors of Research, Ernst and Merchant, of the Cincinnati Milling Machine Company, Cincinnati, Ohio, for their advice and guidance in the planning of this new research laboratory.

SPOT-WELDED WHEELS

Sciaky Automatic Three-phase, Resistance Welding Machines

Automobile wheel with eight spot welds has a shear strength of 45,000 lb

This heavy-duty truck wheel has twelve spot welds of 0.75in diameter

EARLY attempts to produce spot-welded automobile wheels met with indifferent success. Difficulty was encountered in maintaining consistency in the welds and, understandably, wheel manufacturers were reluctant to change their method of production from riveting to welding. It would appear that the lack of consistency arose from wide variation in the welding heat. Even when a good setting had been established, excessive heating and expulsion of metal was likely to occur after some time in production, and with continued production welds would become "cold", with lack of penetration and reduced nugget size. This was found to result from the changing contour of the electrode tips in various stages of deterioration. The effective working life of the electrode tips was short. In endeavours to obtain greater consistency, machines were built in which the electrodes were regularly dressed and re-contoured, and automatic machines were equipped with mechanisms to alternate the electrodes. Such devices were merely palliatives, however, and left the basic problem unsolved.

Three-phase welding machines

It was the advent of three-phase machines that made the spot-welding of wheels practical. Further investigation of the problem revealed that electrode life was shortened by the skin effect due to the sharp rate of rise of the conventional supply frequency of 50 or 60 cycles. This characteristic caused the current to be concentrated around the periphery of the electrode rather than to be evenly distributed throughout the cross-section. The consequence of this was "mushrooming" of the tip and variation of the tip contour and contact area. Pulsation welding gave only a slight increase in electrode life with the conventional supply frequency. The improvement was probably due to enhanced cooling of the electrode during the "off" times, but the characteristic skin effect, and its consequences, still obtained.

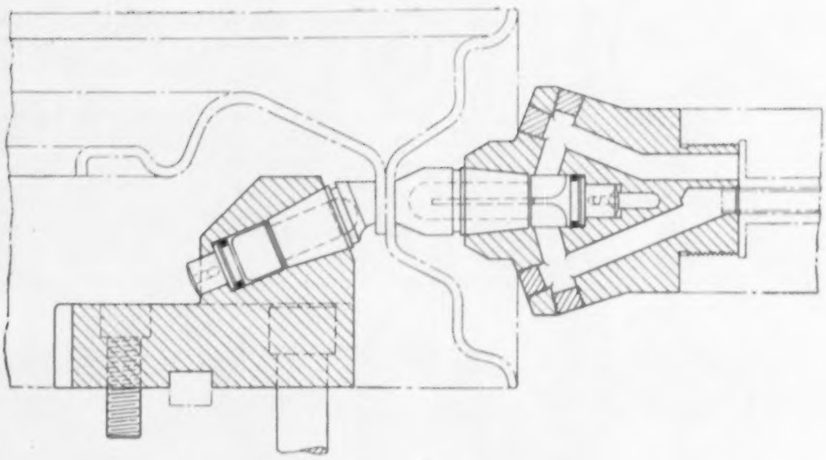
Electrode life was enormously increased by the use of fully rectified three-phase welding current. The secondary current consists of low-frequency alternating pulses having a slow rate of rise. Skin effect was virtually eliminated and heat distribution over the electrode area became uniform. The off time between each current impulse allowed time for the heat to travel throughout the weld zone of the work and cooling time for the electrode. It became relatively easy to maintain the contour of the electrode.

The three-phase system conferred other advantages. Its characteristic of adjusting the secondary current automatically for variations in secondary resistance reduced the shunting of current through previously made spot welds. (Additional current is demanded to replace that lost in shunting.) This characteristic also compensates for variation in work thickness, chemical composition of the work material, and for some variation in tip contour and contact area.

Special attention was given to the design of the internally cooled electrode tips to improve the heat transfer. A round-nosed drill was used in boring the water chamber and a flat baffle plate was fitted therein. This ensured that the incoming water travelled right out to the end of the tip and prevented air bubbles being trapped in the electrode. The chamber was bored to a depth that left a wall only $\frac{1}{4}$in thick between the weld and the cooling water. Improved cooling of the tip substantially increased the working life of the electrode and an average life is now about 60,000 wheels, that is 120,000 welds.

Wheel design considerations

It is of importance that the mating parts of the wheel are



Electrode assembly showing special cooling arrangement to extend tip life

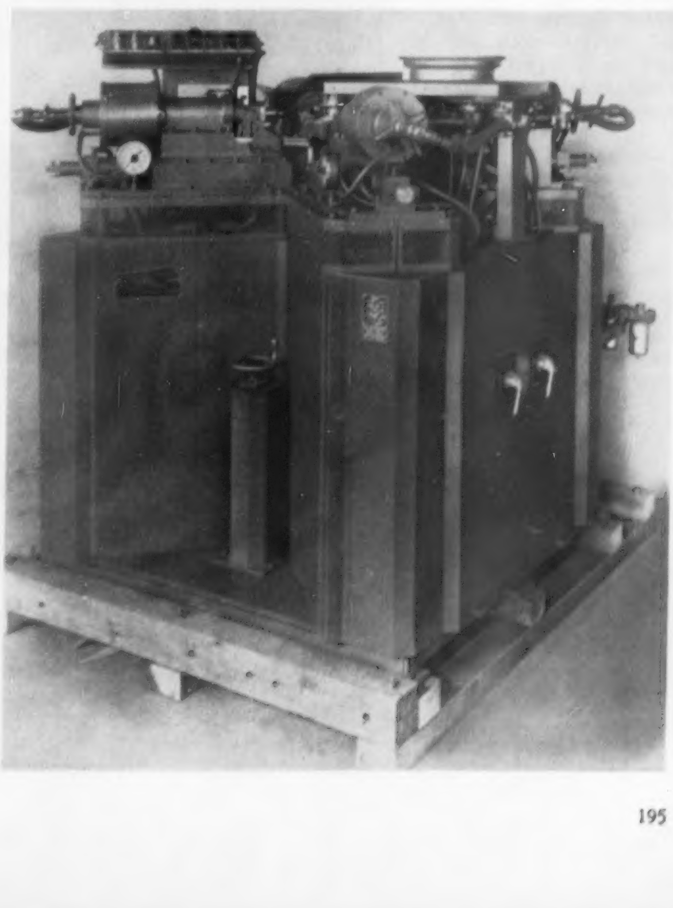
a good close fit in order that the contact area is consistent and the full electrode force is applied to the weld. Commonly an interference fit of the order of 0·040in is arranged between the spider and the rim, and has proved to be satisfactory. The width of the spider flange is increased somewhat beyond that usual in riveted assemblies to provide adequate material for the relatively larger welds. It is desirable that the flat width of the flange should be about 1·0in, with ⅞in as a minimum. This can be arranged without increasing the area of the blank if less material is trimmed from the corners of the blank. The corners of the spider arms are washed out by appropriate shaping of the pressing die so that the press fitting of the spider in the rim will not merely result in local contacts at the corners.

In riveted assemblies it is usual to use twelve rivets. Extensive investigation, experiment and testing established that three-phase, low-frequency welding could produce consistently exceptionally large spots of excellent metallurgical quality and high shear strength. Thus it became possible to limit the number of welds to eight spots per wheel, giving increased economy. In a wheel having a rim thickness of approximately 0·125in and a spider approximately 0·110in, eight spot welds having a minimum nugget diameter of 0·500in had a shear strength of 45,000 lb whereas the same wheel assembled with twelve rivets sheared at 38,000 lb.

Early wheel welders were merely standard general-purpose machines equipped with appropriate electrodes and holders to suit the wheel configuration. These machines made only one spot at a time and the wheel was supported on a fixture and indexed manually to obtain the required number of welds. While the welds were of the stipulated high quality, the rate of production was necessarily limited. Not more than 110–120 wheels per hour could be welded on these machines. Accordingly, special automatic machines were designed for installation in the production line and by making multiple welds the rate of production was considerably increased.

Automatic wheel welders

The first machine for the mass production of spot-welded wheels was the Sciaky MGT-4. This is a table type machine with four sliding, air-operated, direct-acting welding guns mounted horizontally on the top of the machine and arranged at 90 deg to each other. It forms a complete production unit, including automatic indexing, automatic unloading, and welding control, and is capable of handling wheels of from 14in to 20in diameter with eight spot welds. No manual operations are required after the pre-assembled rim and spider has been loaded and located until the completely welded assembly is automatically unloaded. A washing



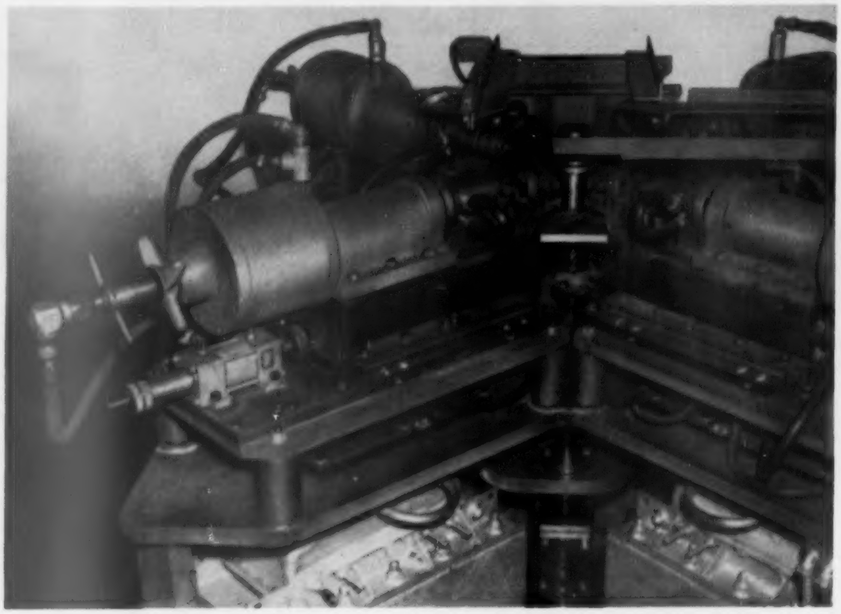
Sciaky MGT-4, automatic indexing, four-gun, wheel welding machine

operation precedes the assembly of the rim and spider. The bath includes a rust inhibitor so that the wheels may, if necessary, be stored before welding.

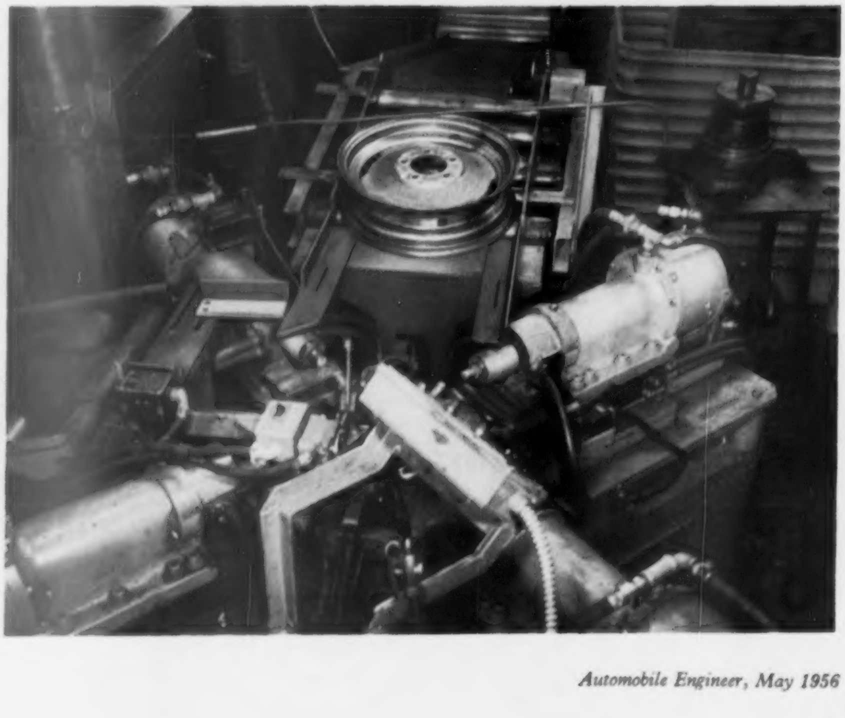
Each of the four welding guns has its own three-phase transformer housed in the box frame of the machine and enclosed by sheet metal covers. All transformers are sealed as a protection against possible water leaks from the cooling circuits above. The gun is attached to a water-cooled, copper alloy yoke mounted in gib slides and is operated by a horizontal air cylinder. A second piston in this cylinder can be positioned by a hand wheel to set and adjust the stroke of the ram to suit the depth of the rim and to minimize air consumption. A small air cylinder is also provided to retract the inner electrode while loading and unloading are carried out. The inner electrode is mounted in an adaptor dowelled and bolted to the gun yoke, and ring type seals are fitted at the drillings for the coolant, so no external connections are required. As a maximum the gun has a welding stroke of 3½in, and an electrode force of 5,000 lb can be exerted with an air line pressure of 80 lb/in². The initial position of the yoke is readily adjustable to accommodate wheels of different diameters.

An elevating platform of a non-magnetic material lowers the wheel from the loading station over a central locating pilot and the wheel is then automatically clamped against a shoulder on the pilot. One of the wheel bolt holes is engaged over a pin on the pilot to ensure correct radial location with respect to the welding electrodes. This pin also serves in connection with the later indexing operation. The platform is mounted on a carriage sliding on vertical guide posts and is operated by an air cylinder, the stroke of which is adjustable to suit rims of different widths.

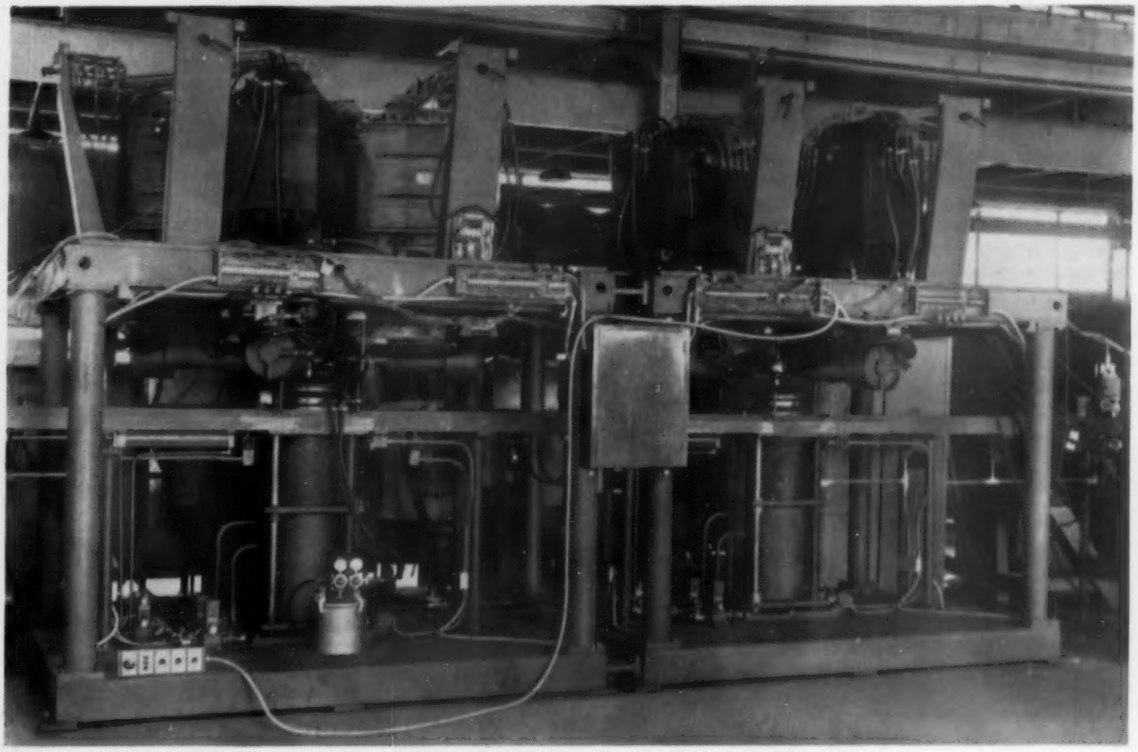
After a group of four welds has been made the wheel is automatically indexed by means of a double-acting air cylinder. The stroke of this component is adjustable so that spider arms of various widths can be accommodated. The automatic unloading device consists of a double-acting air cylinder mounted on a superstructure above suitable



Arrangement of four sliding welding guns on the table of the MGT–4 machine



Overhead view of MGT–4 machine with elevating loading conveyor and lateral unloading equipment

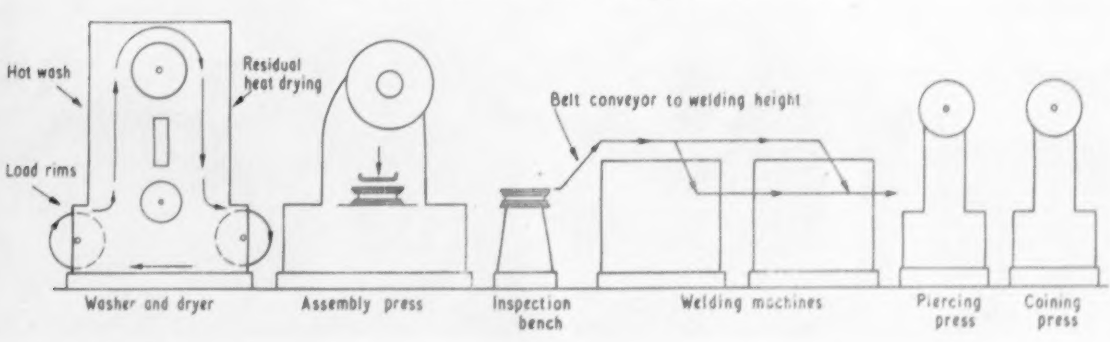


Sciaky MGT–8 fully automatic transfer machine for the production of 700 wheels per hour

guide rails. When the completely welded wheel is raised to the unloading position the unloader pulls it clear of the welding machine and then returns after the succeeding wheel has been lowered to the welding position.

Mechanical functions of the machine are initiated by push buttons and limit switches, with suitable cut-out controls for emergency stops. In automatic operation the sequence of the machine is initiated by loading a wheel against a limit switch. The initial radial location of the wheel when loading is the responsibility of the operator. The wheel is fed to the machine on a smooth surface, guided by rails, on to the platen where it is pushed to a stop, which also forms a rail for guiding the wheel off the machine. In position against the stop it actuates a limit switch which causes the platen to lower the wheel to the welding position. Three limit switches arranged in series check that the wheel is in the correct welding position and is horizontal. The closing of all three switches actuates the holding-down clamp and causes the welding guns to advance. Four welds are then made simultaneously in the corners of the spider arms and the gums are retracted. The indexing mechanism turns the wheel into position for the next group of welds in the opposite corners of the spider arms and the guns are again advanced. At the end of the second welding operation the guns are retracted and a limit switch causes the platen to raise the wheel to the unloading position and immediately the unloading device pulls the wheel clear of the machine. The feeding of the succeeding wheel into the loading position restarts the sequence and when this wheel is lowered over the centre pilot the unloader commences its return stroke.

Schematic layout of production line for 770 wheels per 60-minute hour



The welding transformers, nominally rated 125 KVA at 50 per cent duty cycle, are specially designed and constructed to operate efficiently and without overheating at the exceptionally high duty cycle at which the machine is operated. It demands 160 KVA per gun, or 640 KVA for four guns operated at the same time. A Sciaky three-phase control of the synchronous electric type is provided to fire the four transformers simultaneously. The control includes squeeze, weld interval, synchronous heat, synchronous cool, and hold timers, and also a phase shift heat control. Integrating the various functions of the machine, as well as the control of the welding cycle, is a master sequence control. Interlocks are provided to avoid the possibility of accident. A typical weld setting is 4 cycles of heat, 4 cycles of cool, 9 impulses at 90 per cent phase shift, and an electrode force of 4,000 lb. One customary practice is to use 4 cycles of heat and 4 cycles of cool for all sizes of wheel, varying only the number of impulses, phase shift, and pressure for different wheel thicknesses.

The optimum operating cycle of the MGT-4 machine, as analysed by time study, is as follows:

	Function	*Cycles*
1.	Limit switch makes; air exhausts from lift cylinder	20
2.	Platen lowers to welding position	17
3.	Welding guns move in; contact gauge makes	22
4.	Squeeze time	16
5.	Weld time, 13 impulses, 4 heat—4 cool	106
6.	Hold time	33
7.	Welding guns retract; wheel is indexed; guns move in	48
8.	Squeeze time	16
9.	Weld time, 13 impulses, 4 heat—4 cool	106
10.	Hold time	33
11.	Welding guns retract; platen rises to unloading position	48
12.	Wheel unloaded	30
	Total time, machine	495 = 8·25 sec
	Loading time, assumed	0·93 sec
	Total time per wheel	9·18 sec

Total production is thus 392 wheels per 60-minutes hour or 326 wheels per 50-minute hour.

Typical production line

A typical production line, set up for a rate of 770 wheels per 60-minute hour is illustrated schematically. It comprises a conveyorised washing and drying machine for the rims, an assembly press, an inspection bench, two MGT-4 welding machines, a press for piercing the valve hole and a press for coining the rim to receive the decorative wheel covers. The line is separated from the rim rolling line and the spider

Testing the strength of a welded wheel by forcing the spider out of the rim and tearing out the weld slugs

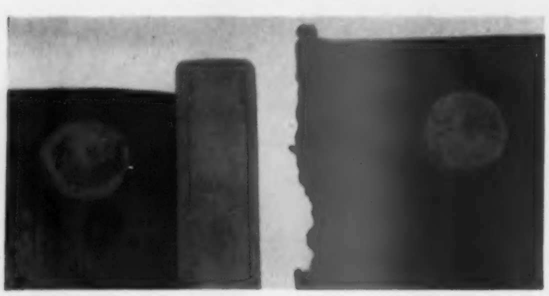
production line. Eight men are required to run the line. One man loads the rims on to the washer conveyor, the rims being hot-washed while travelling vertically up one side of the machine and dried by residual heat while being returned down the other side. Three men service the assembly press. The first takes the rim from the washer and loads it into the press; the second takes the spider from a rack and places in the rim on the press; the third takes the wheel assembly from the press and checks it on the inspection bench. The two welding machines and the two presses are each operated by one man.

All electrodes are checked every 55 min. and re-faced, if necessary, every 4 hr. Average life of the electrodes is 60,000 wheels for outer tips and 40,000 wheels for the inner tips. The nugget diameter is maintained at not less than 0·500in.

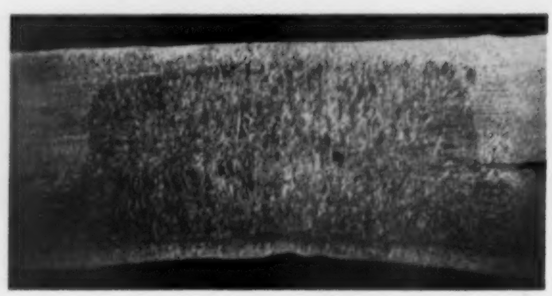
Automatic transfer wheel-welding machine

For a higher rate of production the fully automatic MGT-8 machine has been developed. In essentials, this comprises two inverted MGT-4 welding machines connected by a transfer conveyor system. Each of the welding units makes four of the eight welds on each wheel. The conveyor carries the wheel through the entire sequence of operations, including pressing the spider into the rim, welding the wheel

Typical welds cut from a wheel and then sheared under test. Minimum nugget diameter is 0.500 in



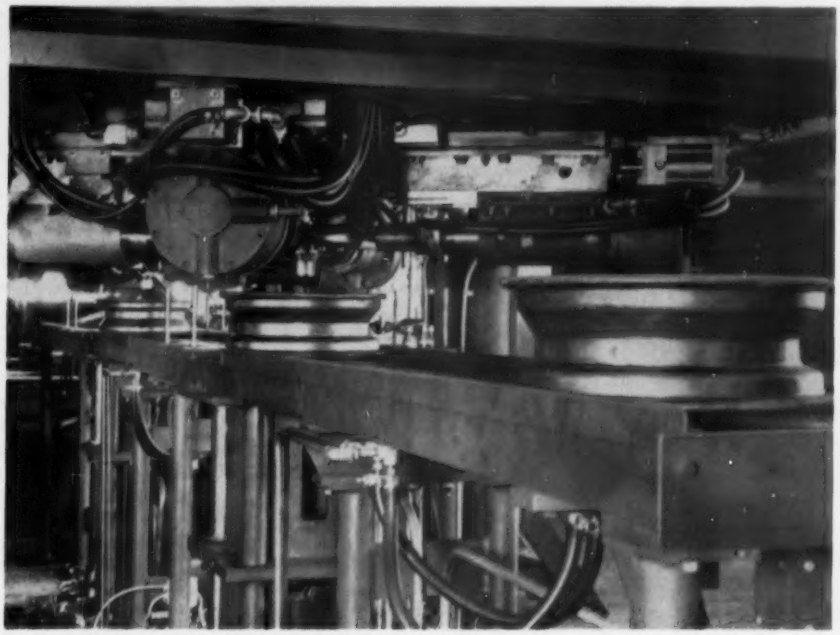
Weld cut from a wheel and cross sectioned and etched for metallurgical inspection



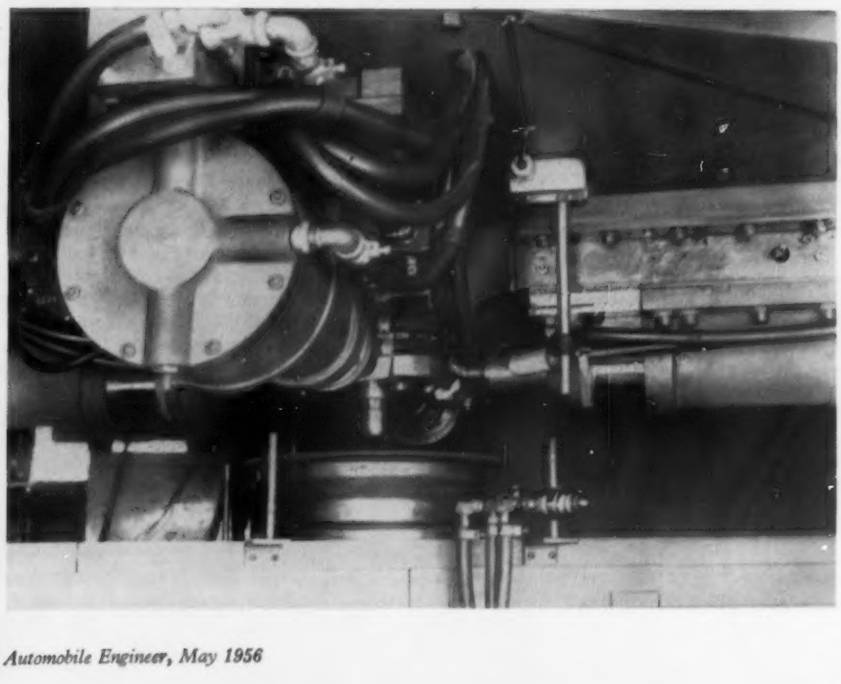
assembly, automatically checking the quality and consistency of all welds, and punching out and dimpling the valve hole. The two welding units are each of four-post construction with fabricated steel base plates and crown plates suitably reinforced to minimize deflection. On the crown plate are suspended the sliding welding guns and above are supported the welding transformers. The guns are mounted on an adaptor plate that provides adjustment of the angular relationship of the two groups of guns between 30 deg and 45 deg, to vary the spot location for different sizes of wheels and for different spiders. Construction and mounting of the welding guns follows the arrangement on the MGT-4 machine. On that machine the wheels were carried over the guns and lowered into the welding position but on the MGT-8 the wheels are transferred below the guns and are raised to the welding position by an air cylinder and guiding mechanism. After welding, the wheel is lowered back on to the conveyor for transfer to the next station.

At the pressing station the spider is fitted into the rim by means of a 12in diameter air cylinder. The pressing dies are designed for easy and rapid removal and replacement when changing over the tooling for wheels of different sizes. The alignment and location of the component parts are effected by the centre pilot and the dies themselves. This is of importance, since once the wheel is assembled and welded, run-out and misalignment cannot be rectified. Radial orientation of the wheel, to ensure the correct location of the arms of the spider with respect to the welding guns, is accomplished on the transfer mechanism.

The last two stations of the machine are for punching and dimpling the valve hole in the rim. Each of these press units consists of a 12½-ton hydraulic cylinder fitted to a sliding yoke and loaded by heavy springs so that the stationary die clears the rim during transfer operations. They are mounted to apply the press force normal to the appropriate surface of the rim and are fully adjustable to handle wheels of different diameters and rim sections. The guide rails for the wheel at these stations engage the tyre-bead seat of the rim. Thus, after punching and after dimpling, the wheel



On the MGT-8 machine the conveyor carries the wheels below the suspended welding guns



Every weld is examined by a photo-electric cell and a defective weld is automatically indicated by a shot of paint

is held down while the tools are stripped from the work under the action of the loading springs. The hydraulic power unit furnishes a 1,000 lb approach pressure and a 5,000 lb operating pressure.

Much thought and development has been given to the transfer mechanism which must hold the wheels firmly and move them rapidly and precisely in order to maintain the rate of production. Approximately 30 cycles, or 0·5 sec, are required for a wheel to be grasped and transferred from one station to the next, a distance of about 19in.

Automatic weld checking

Each individual spot weld on the wheel is automatically inspected and evaluated by the Sciaky weld checker. This device examines the weld immediately after it has been made and if its quality does not conform to a predetermined value it is automatically indicated with a shot of red paint so that later the inspector can locate and examine the wheel. The weld checker utilizes a photo-electric cell unit in conjunction with a bridge circuit to test the quality of the weld. Infra-red radiation from the completed weld energizes the photo-electric cell and thereby brings the bridge circuit into balance. Should the weld be too cold or too hot the radiation will be too little or too much and the bridge circuit is unbalanced. In such circumstances a relay is energized to start a sequence that delivers a shot of red paint from an appropriately mounted spray gun. The checker may also be equipped with visible or audible signal devices to inform the operator when a questionable weld has been made, and thus minimize the production of sub-standard components.

Wheels having a weld that does not conform to standard are set aside, examined, and in suitable cases can be recovered by adding a weld close to the sub-standard spot. This work is done on a standard single-piont welding machine. The checker is adjustable to the desired heat required for a high quality weld on a specific wheel and is quite sensitive to variations from the pre-set value.

The operational sequence of the machine is:

1. Rim automatically loaded on conveyor
2. Spider manually loaded on rim and oriented with respect to the welding guns
3. Spider pressed into position
4. Four welds made in first welding machine; welds checked
5. Wheel transferred to second welding machine; four welds made; welds checked
6. Valve hole punched; hole dimpled
7. Unloaded

The sequencing is arranged so that the first and second welding machines are operated at different times in order to reduce the power demand, but in such manner as to avoid any loss of time in the operating cycle. When the second machine is welding, the first machine is moving a wheel into position by raising it up to meet the electrodes and moving the welding guns into contact with the wheel preparatory to welding. While the first machine is welding, the second machine retracts the welding guns from a completed wheel, lowers the wheel to the conveyor and, as the wheel is moved out to the valve hole punching station, the next wheel to be welded is moved into position ready to be raised to the electrodes.

Nominally the MGT-8 machine is designed for the production of wheels at the rate of 700 per hour. That this rate can be comfortably exceeded is shown by the following study of the operating cycle:

Function	*Cycles*	*Sec*
1. Transfer movement	30	0·50
2. Platen rises	47	0·78
3. Guns move in; squeeze time	25	0·42
4. Weld time, 13 impulses, 5 heat—2 cool	91	1·52
5. Hold time	16	0·27
6. Guns retract	15	0·25
7. Platen lowers	52	0·87
Total time	276	4·61

At 100 per cent efficiency, that is, a 60-min hour, this figure gives a production rate of 780 wheels per hour.

Testing welds and wheels

Various destructive tests are employed by the manufacturers of the machines, Sciaky Welding Machines Ltd., Farnham Road, Slough, to evaluate the quality of welds and to compare the relative strengths of welded and riveted wheels. One of the tests is to use either a press or a tensile testing machine to extract the spider from the rim and then to inspect the welds. The manner in which the test is conducted results in a combined tensile and sheer load on the welds. They are considered to be of good quality if all of them pull slugs of material out of the metal and reveal a weld nugget of at least 0 500in diameter, as shown earlier. Welds are also frequently cut out of a wheel and then sheared individually in a tensile testing machine or cross-sectioned, polished, and deep etched for metallurgical examination. Hardness checks are also made at various points in the weld nugget and the adjacent base material.

Destructive tests on complete wheel assemblies are made by a variety of methods. In one of these the wheel, complete with tyre, was supported at an angle of 30 deg from the horizontal and a weight of 2,020 lb was dropped upon it from heights of 1 ft, 2½ ft and 3 ft. Rim, spider and hub were damaged beyond repair but the welds were not impaired. A similar wheel having a riveted assembly could withstand a drop of only 7in by the same weight.

In another test a wheel complete with tyre was clamped horizontally to the table of a Bullard machine and rotated at a speed equivalent to a vehicle speed of 20 m.p.h. A shaft 4 ft long was bolted to the spider of the wheel and at the end of this was imposed a lateral load of one-fourth of the vehicle weight with a 60 per cent overload, that is 1,040 lb. On this test a riveted wheel was considered satisfactory if it would survive 27,000 revolutions. The welded wheel withstood 189,000 revolutions before failure occurred at the spider bolt holes. The welds, however, were still in good, sound condition.

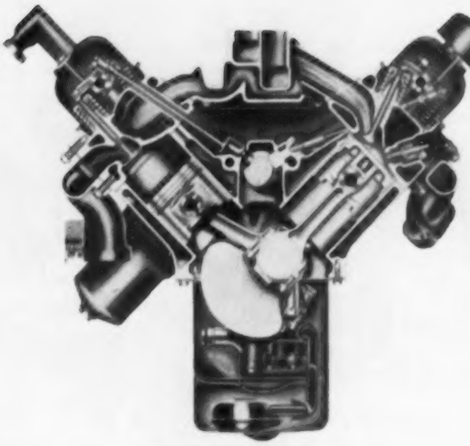
Mechanical Handling

Two special issues of our associated journal *Mechanical Handling* will deal with the 5th Mechanical Handling Exhibition and Convention, which is to be held at Earls Court, London, from 9th to 19th May. The first of the special numbers will be the May Exhibition Preview, and the second will be the June Exhibition Report. Both will be published at the normal price, 3/-.

The Preview number will be published just previous to the opening day of the Exhibition, May 9th. It will contain a full list of exhibitors, a plan of the Exhibition, and details of times and subjects to be discussed at the Convention. In addition it will contain all the normal features dealing with every aspect of industrial mechanization.

The Exhibition Report will be published on June 11th. It will contain details of the opening ceremony; a fully illustrated report of the equipment displayed; pictorial interviews with distinguished visitors; and a full Convention report.

In addition to their great topical interest, these two special issues will be of value as reference works. Copies can be obtained from all newsagents, or direct from Iliffe and Sons, Ltd., Dorset House, Stamford St., London, S.E.1.



Chrysler Plymouth V-8

V-8 ENGINES

A Review of Current Engine Designs in the United States of America

AT least nine out of every ten motor cars manufactured in the United States in the last year were fitted with V-8 engines. In fact, it is now nearly ten years since new tooling has been set up to manufacture any other type of automobile engine in that country; what few in-line engines are still required are produced on old tools. It is therefore worth while to review the advantages of the V-8 engine which have brought it almost universal use, to describe the engines now in production and to examine a typical engine critically from the points of view of design and all-round performance.

History

The first V-8 engine of which we have any record seems to have been the Antoinette aircraft and marine engine of about 1903. This was followed by a Rolls-Royce V-8 engine in 1905 and, a few years later, by a DeDion-Bouton engine of the same type. The chapter of engine development that interests us here may be said to have commenced with the Cadillac V-8 engine of 1914. This was the first engine of the type to go into series production and the only engine which—apart from a brief excursion into a V-12 and a V-16—has been under constant development ever since.

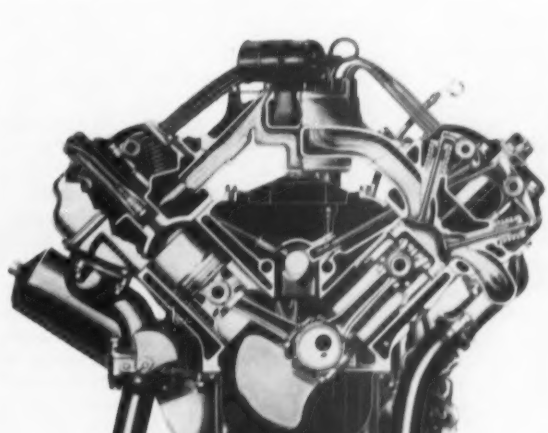
As originally produced, this engine had a single-plane crankshaft and therefore had a resultant secondary unbalance, a force which tended to move the engine horizontally from side to side. In spite of this, the 1914 Cadillac engine appeared to be extremely smooth and quiet in comparison with other engines of that day. In 1926 this unbalance was eliminated by the introduction by Cadillac of the 90-180-90-deg crankshaft, with the crankpins in two planes. With the change from side valves to overhead valves in 1949, this engine may be said to have started the move toward the universal use of V-8, overhead-valve engines in the U.S.A.

Another engine that deserves mention is the V-8 Ford engine, first produced in 1932. At the time, one wondered how an 8-cylinder engine could possibly be produced at a cost to compete in the low-priced field, yet this engine has been in constant production ever since and no less than 21,400,000 engines of the type have now been manufactured by the Ford Company. Until 1949, however, Cadillac and Ford were the only large-scale manufacturers of V-8 engines in America. So the change-over to the V-8 type has been rapid and today, apart from lorry and tractor engines, there are indeed few petrol engines of any other type still in production.

Advantages

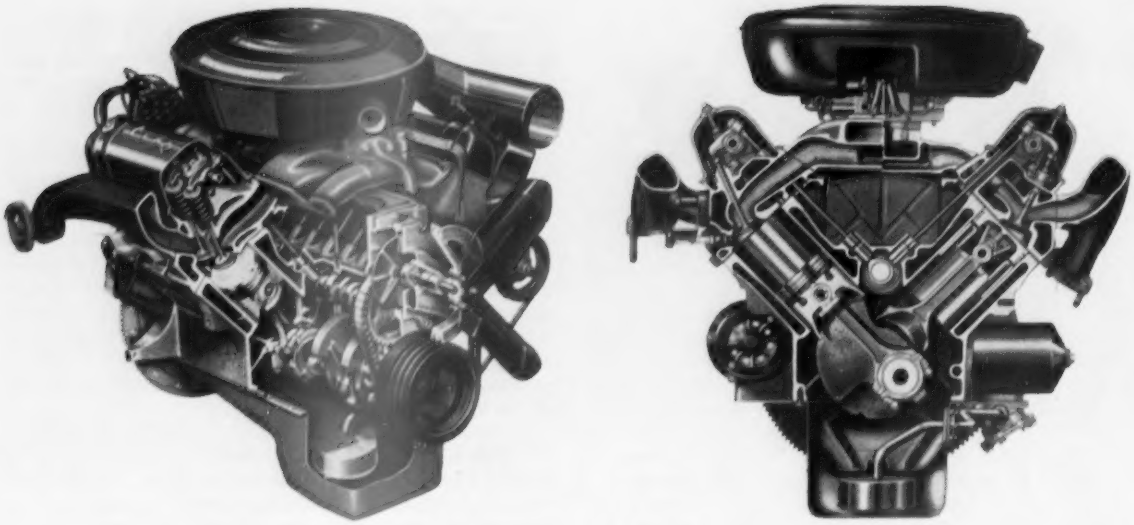
This universal trend toward the overhead-valve V-8 engine in America can be ascribed to two factors—the constantly-increasing anti-knock quality of the fuels available, now up to 100 octane, and the ever-increasing use of automatic machinery. This transfer-type machinery has made it possible to produce engine parts with finished surfaces in almost any location without cost penalty, provided that the cutting tools can be worked in without any great increase in the number of stations.

Investigation has shown that, of all possible engine types, the V-8 layout possesses the majority of advantages for smooth running at high compression ratios. Inherently it has a rigid crankshaft and crankcase. For a typical crankshaft, the 4th mode of torsional vibration will synchronize at about 5,000 r.p.m., while the deflection of the flywheel on account of the working load on the rearmost crankpin is exceedingly small.



Chrysler Firebird V-8

It has been found that, for satisfac'ory operation at high compression ratios, an engine must have cylinder bores that stay round, rigid pistons and connecting-rods, durable bearings and high-voltage ignition. A considerable number of standard engines have been converted to compression ratios as high as 12 : 1, and have run very satisfactorily at these ratios. Incidentally, the V-6 engine has also been thoroughly investigated and a number of samples built, but this type has not proved so satisfactory as the V-8 engine.



Ford Lincoln V-8. Displacement 368in³

Power output

In considering the performance of present-day American engines, it will be convenient to set up a typical, or average engine. The reader may wish to compare this performance with that of the Chrysler V-8 engine of four years ago, which was described in the March 1952 issue of *The Automobile Engineer*.

From the following table, which includes all American V-8 motor car engines now in production, we may select a typical engine, somewhat larger than average, with a displacement of 350in³ (5·8 litres) and a bore and stroke of 4in × 3½in. With a compression ratio of say 9 : 1, this engine, bare, could be expected to give about 220 h.p. with a single, duplex carburetter and perhaps 280 h.p. with high-lift cams and two quadruplex carburetters. These figures correspond to 0·63 h.p./in³ and 0·80 h.p./in³ respectively and, assuming that they would be obtained at 4,600 r.p.m., would also correspond to 72lb/in² and 92lb/in² b.m.e.p. at that speed. The average of all the rated maximum torque outputs of these engines is close to 1lb-ft/in³, which corresponds, of course, to 151lb/in² b.m.e.p.

Now it will no doubt be pointed out that the horsepower figures given in the table are "advertised" figures, drawn on graph paper borrowed from the Engineering Department by the Sales Department, so that the engines may compete in the fantastic American "horsepower race". This is undoubtedly true, but the figures we have selected above are rather lower than the advertised figures and could, we believe, be obtained from a carefully-tuned engine under ideal conditions of intake air temperature, exhaust back-pressure and so on.

It must be remembered that, in each Engineering Department concerned, there has been, for some years past, a small group of engineers assigned continuously to the problem of obtaining more output from an engine to be manufactured on a given set of tools.

This unending search for an increased power output has made progress by taking much the same steps as the amateur racing, or "hot-rod" enthusiasts, including :—

Increasing the cylinder bore.

Fitting one or two four-barrel carburetters.

Increasing the compression ratio.

Increasing the intake port diameter.

Increasing the exhaust port diameter, smoothing the ports and easing the bends in the exhaust pipe; fitting two exhaust pipes, one from each bank of cylinders.

Increasing the valve-opening periods, increasing the cam lift or the rocker-arm ratio.

Fitting mechanically-adjusted tappets, where hydraulic tappets have given trouble at high speeds from "pump-up".

Lowering the engine friction.

Many of these changes can be considered as healthy developments, in that they quickly show up poor combustion-chamber design, springy valve gear, too light pistons and so on. That is, they tend to improve the breed. High power outputs have come in for much criticism on the part of those interested in safety on the road; they can be justified to an extent by pointing out that high torque at high engine speeds makes overtaking easier and thus possibly safer; furthermore, the engine has an ever-increasing accessory load, which now includes in most cases a hydraulic pump for the servo-assisted, or "power" steering and, in some cases, a compressor for the air-conditioning system.

Whatever the merits of the case, it is interesting that, at the beginning of this year, several manufacturers have offered, either as standard or as an extra, their highest-output engine for every chassis model in which it can be fitted.

A typical engine in this American V-8 group has a bore of 4in × 3½in and a displacement approximating to 350in³. The crankshaft is of forged or cast steel, with integral counterweights. The crankpins are 2¼in in diameter and the main journals 2½in in diameter, so that the crankpins overlap the main journals by ⅝in. The main journals are of the same length, except the rearmost, which is usually twice as long as the others. Both the foremost and the rearmost crankshaft cheeks are almost twice as wide as the remaining cheeks, in order to minimize deflection at the flywheel and to ease the counterweight problem. A small torsional damper, either of the moulded-rubber or bonded-rubber type is usually fitted at the front end of the shaft. The flywheel is exceptionally light, being little more than a thin steel disc, plus attached parts of the automatic gearbox.

The length of the connecting-rod, centre to centre, is 6⅝in in an engine of this size, or 1·9 times the stroke. The connecting-rod cap is secured by two bolts, fitted with self-

locking nuts. The pistons are of aluminium, have flat heads and comparatively short skirts, which are cut away at the sides to clear the counterweights. They tend to become heavier in section as compression ratios are increased, and are fitted with two compression rings and one oil-control ring, all above the piston pin. The piston pin diameter is just under 1in.

The design of the cylinder block follows a conventional pattern, the only controversial point being the location of the lower, or sump face, which may be either at or close to the plane of the crankshaft axis or several inches lower. The lower location is a feature of the Ford group of engines, which are described in advertising as "Y-8", rather than V-8 engines. The camshaft is located close to the centre of the block and is driven by inverted tooth chain in most designs, but in one engine by "Celeron" and steel gears. The distributor and oil pump are driven from the camshaft, towards its rear end, by spiral gears.

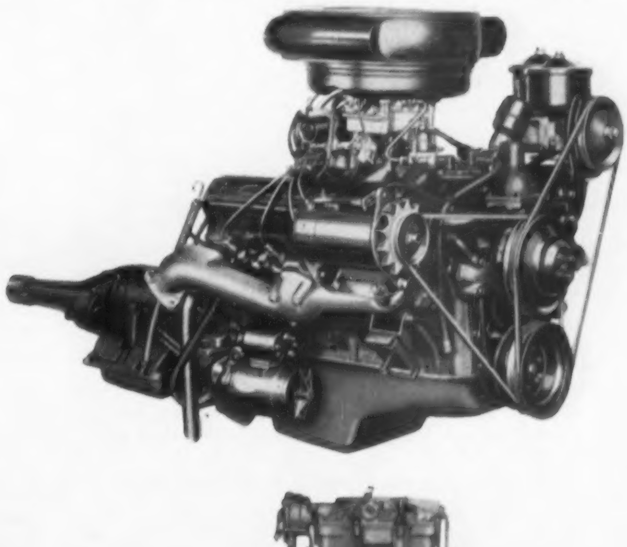
The cylinder head design is also fairly uniform, with variations in the angle of the valve guides and in the slopes of the intake and exhaust faces. Cylinder heads are interchangeable between the right and left banks. Great care is taken in locating the cylinder head holding screws, so that their bosses in the block will have no contact with the cylinder sleeves. The purpose of this precaution is, of course, to avoid distortion of the cylinder bores when the head screws are tightened.

The valves are generally placed side by side more or less in the plane of the cylinder axes. This is undoubtedly the simplest and cheapest arrangement, although the valve-ports are restricted and it is difficult to ensure proper cooling of the exhaust-valve seat. In several designs, the mixture flow past the intake valve head is restricted by the close fit of the walls of the combustion chamber.

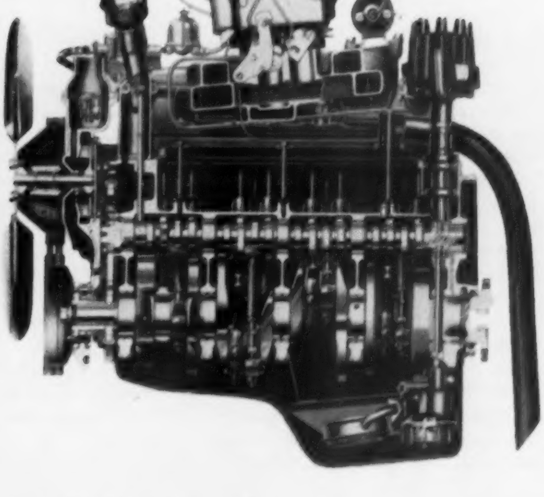
Valve gear

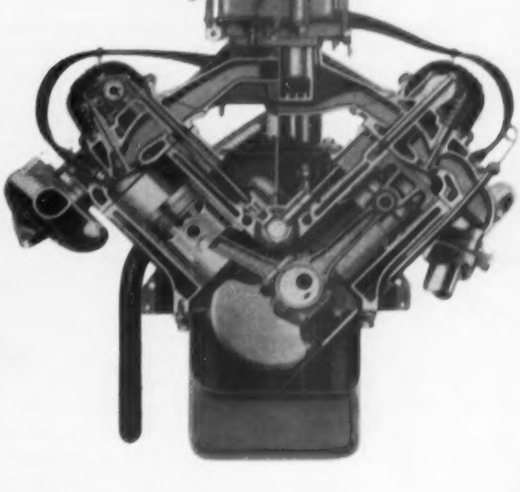
A neat solution to these problems is found in the Chrysler design. In these engines, the valves are arranged transversely across the cylinder and are inclined, an arrangement that has, of course, long been standard in aircraft engines. This affords room for larger valves, with excellent valve-seat stability and cooling and with excellent flow conditions about the valve heads. The sparking plug may be placed within ¾in of the cylinder axis and no part of the combustion chamber overlaps the cylinder bore, so flame travel conditions are excellent; in fact, the combustion tends to be somewhat rough. Against this, two valve rocker-arm assemblies are required for each cylinder head, there are a number of odd angles at which holes must be drilled and faced and a sealing tube is needed for each sparking plug.

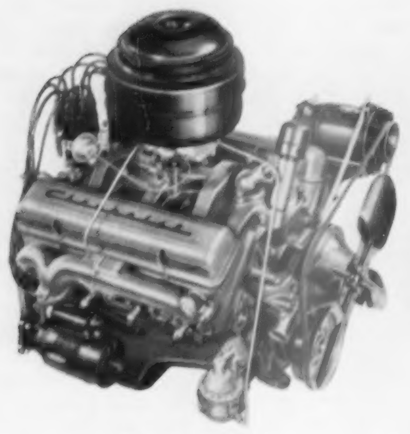
An interesting compromise has been worked out for the smaller engines of the Chrysler group. In these, only one rocker-arm shaft is used in each cylinder head and the sparking plugs have been brought outside the cylinder head



The 1956 Cadillac V-8 shown in these three illustrations has $365in^3$ displacement







1956 Chevrolet V-8

covers. The effect of this is to reduce the cost of the engine slightly, perhaps by about £1-10-0 per unit, at some compromise to the exhaust-valve port design.

Another interesting departure from the conventional is found in the Pontiac and Chevrolet engines. In these designs, no rocker-arm shaft is used at all and each individual sheet-steel rocker arm is retained by its own stud, ball-end spacer and nut. The studs are pressed into the cylinder head and, in the original design, were drilled to carry oil from a longitudinal gallery to each rocker arm; it was later found possible to lubricate the rockers from the hydraulically-adjusted tappets. Incidentally, the rocker arms are self-aligning transversely, with respect to the valve-stem tips.

The push-rods are exceedingly simple steel tubes, with either inserted tips or rounded ends. It is noteworthy that valve-guide inserts are not used, the valve stems being directly in the head. This not only reduces cost but also lowers the temperature of the exhaust valve head by some 50 deg F, though probably at some cost in durability.

Apart from these items, the design of the valve gear is usually straightforward. Self-adjusting hydraulic tappets are used in the majority of these engines and are supplied from either one oil gallery drilled above the camshaft tunnel, or two galleries drilled alongside this tunnel. In several of the "sports" engines, the hydraulic tappets are omitted and plain mechanically adjusted tappets substituted, since the former are inclined to give trouble with pump-up at engine speeds around 5,000 r.p.m., a speed above which resonance in the valve gear and valve springs is usually troublesome.

The camshaft is driven from the front end of the crankshaft, nearly always by inverted tooth chain. A typical valve timing would be:—

I.O.	20 deg B.T.C.
I.C.	55 deg A.B.C.
E.O.	50 deg B.B.C.
E.C.	15 deg A.T.C.

Combustion chamber

The most fruitful source of disagreement concerning these engines lies in the design of the combustion chamber. All have overhead valves, almost all have compression ratios in the range between 8 : 1 and 10 : 1, but there the uniformity ends. Their design varies from a simple, "open" chamber in the Chrysler engines, to the more complicated chamber of the Buick engine, which consists of a simple enough penthouse cavity in the head, coupled with a comparatively complex domed head on the piston, which must tend to increase the piston-head temperature.

The majority of the combustion chambers used in American V-8 engines are based on an arrangement of the valves longitudinally, in a plane parallel to that of the crankshaft and inclined at about 15 deg to the cylinder axes, so as to bring the valve stems and the overhead valve gear in toward the centre of the engine, for compactness. In the Buick design, this angle is 45 deg, so the valves are vertical when assembled in the engine. The exceptional Chrysler design has already been mentioned.

The conventional valve arrangement does not leave a great deal of latitude in the design of the combustion chamber. It becomes a problem of how best to ease the flow conditions about the intake valve head, how to place the sparking plug where it will be accessible and yet obtain a minimum flame travel, and how much of the area above the piston will be flattened off, to serve as quench area. This quench area will usually be about 45 per cent and should be kept high, since roughness is not a problem with engines of this type, well mounted in rubber supports.

Compression ratios are high, even as high at 10 : 1, as mentioned above. This leads to the question of machining the entire combustion chamber. With careful work in the foundry, the machining of the cylinder head located from the combustion-chamber roof and close tolerances on the crank throw, connecting rod length and so on, it is possible to control the compression ratio of an as-cast combustion chamber to about ± 0·35 of a ratio. This does not seem close enough and it is now possible completely to machine even quite complex chambers (for example the Packard chamber) without adding greatly to the cost.

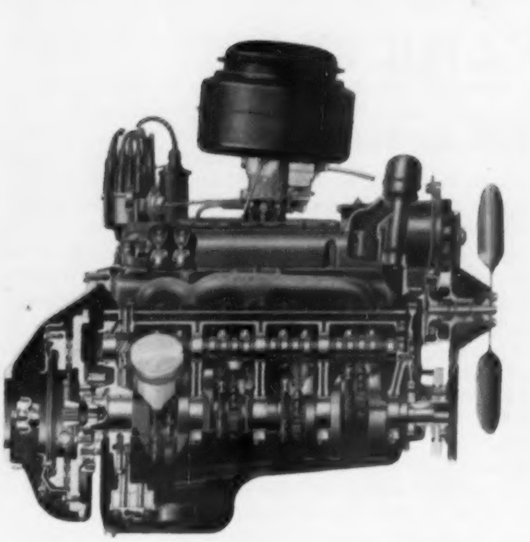
Fuel system

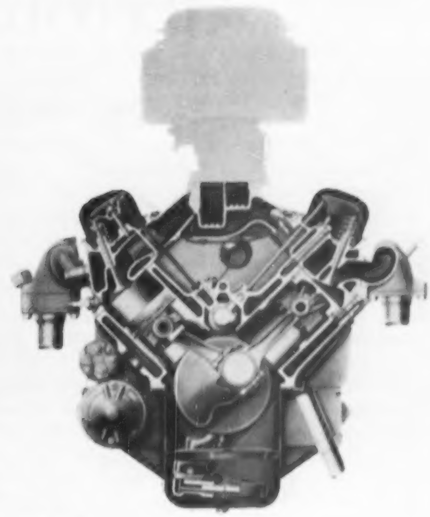
The only essential difference in the fuel systems of these engines is the number of carburetters fitted. These consist of either a single duplex (two-venturi) carburetter, a single quadruplex (four-venturi) or "four-barrel" carburetter, or two quadruplex carburetters. In the constant search for greater power output, the tendency is to provide the latter pair. In all cases, fuel is supplied by a mechanically-driven fuel pump and air is supplied through a large air cleaner, which has been much flattened, to permit the lowest possible body lines. In a few cases, the air is drawn from outside the engine compartment.

Intake manifolds conform strictly to one type. Numbers 1 and 4 left cylinders and numbers 2 and 3 right cylinders are supplied from one venturi (or pair of venturis) and the remaining cylinders from the other venturi (or pair). In plan view the manifold thus resembles two superimposed H's.

In the past, the two exhaust manifolds have usually been connected to a single exhaust pipe, but the tendency is to provide two separate exhaust systems, one for each bank of cylinders. Heat for the intake manifold hot-spot is invariably obtained by a short cross-connection between numbers 2 and 3 exhaust ports of one bank to the directly opposite exhaust ports of the other bank of cylinders. This connection passes through the intake manifold on its under side. Until the engine warms up, exhaust gases are forced through this connecting pipe, by a thermostatically-controlled blocking valve in one exhaust pipe. So long as this valve is closed, the exhaust from one bank must find an exit through the centre exhaust ports and the exhaust pipe of the opposite bank of cylinders.

In every case, a combined water pump and fan unit is mounted at the front end of the engine directly above the crankshaft and is driven at, or slightly less than engine speed by means of a belt. The dynamo is mounted high up, either on the right or left side of the engine and is usually





Displacement of this 1956 Chevrolet engine is 265in³

driven by the same belt. It is arranged to swing, for belt tension adjustment.

Basically, then, the accessory layout is extremely simple. Unfortunately it does not end there; there are now two other accessories which have nothing whatever to do with the engine, for which space must be found. The first is the hydraulic pump for the servo-assisted, or "power" steering gear, now fitted to about 50 per cent of all American cars manufactured. This is usually mounted on the rear end of the dynamo, so that no additional drive need be provided. Finally a compressor for the air-conditioning system must be fitted to about 10 per cent of current-production engines. This unit is mounted high up on the side of the engine opposite to the dynamo and is usually driven by a separate belt.

In America, the trend toward the use of V-8 engines is now almost universal in motor cars and is rapidly spreading into commercial vehicles. It is the result of the availability of fuels of up to 100-octane anti-knock value and a demand for quietness and smoothness, coupled with high maximum power output, in engines of even the lowest-priced models. Automatic transfer-type machinery has made it possible to manufacture V-8 engines at a very low cost—extremely low, when measured in man-hours, rather than wages. V-8 engines are fitted to motor cars which, to American standards, provide little more than bare transportation and to cars in the very highest price class.

As to the next step, it seems likely that the V-8 engine will occupy its leading position in America for some years to come. Fuel injection will probably replace the carburetter in at least one American engine late this year and some work is being done on turbo-blowers for supercharging. Perhaps the next important move will be to gas turbines, say in about 6 or 8 years time, a development which goes steadily forward, but is held up at the moment by the difficulty of designing a satisfactory heat exchanger. Meanwhile, the V-8 engine is still undergoing intensive development and will prove difficult to oust from its present position.

1956 AMERICAN V-8 ENGINES

Group	Make	Bore and Stroke in	Displacement in³	Rated output h.p.	Compression ratio, : 1
American Motors	Hudson and Nash	4·00 × 3·50	352	220	9·55
Chrysler	Plymouth	3·63 × 3·25	270	180 and 189	8·0
		3·75 × 3·13	277	187	8·0
		3·81 × 3·32	303	240	9·25
	Dodge	3·62 × 3·80	315	218 and 230	8·0
	De Soto	3·72 × 3·80	330	230 and 255	8·5
	Chrysler	3·81 × 3·62	331	225 and 250	8·5
		3·94 × 3·62	354	280 and 340	9·0
Ford Motor	Ford	3·62 × 3·30	272	173 and 176	8·0 or 8·4
		3·75 × 3·30	292	200 and 202	8·0 or 8·4
	Mercury, Thunderbird	3·80 × 3·44	312	210 to 225	8·0 to 9·4
	Lincoln, Continental	4·00 × 3·66	368	285	9·0
General Motors	Chevrolet	3·75 × 3·00	265	162 to 225	8·0 or 9·25
	Pontiac	3·94 × 3·25	317	205 and 227	7·9 or 8·9
	Buick	4·00 × 3·20	322	220 and 255	7·6 to 9·5
	Oldsmobile	3·87 × 3·44	324	230 and 240	9·25
	Cadillac	4·00 × 3·62	365	285 and 305	9·75
Studebaker-Packard	Studebaker	3·56 × 3·25	259	170 and 185	7·8 or 8·3
		3·56 × 3·62	289	195 and 210	7·8 or 8·3
	Packard	4·00 × 3·50	352	240 and 275	9·5
		4·12 × 3·50	374	290 and 310	10·0

AUTOMOBILE BRAKES

*Considerations Affecting Fade and Stability**

J. W. Kinchin †

BRAKING problems during the post war years have become greater as the years pass, for the reasons that vehicle weights have increased, maximum speeds have increased, acceleration has increased and to make things worse there is a tendency to reduce wheel sizes. This reduction in wheel size involves the adoption of a larger tyre section, and this in conjunction with the lower silhouettes and wrap-round mud wings has meant that the air flow over the brake drums has also been reduced. Therefore, many conditions have combined to render the provision of adequate brakes more difficult. At one period it is probable that sufficiently light pedal efforts were a problem, particularly in view of the increase in vehicle weights but on the American market particularly this has been met by the provision of vacuum boosters on many cars, while on the European market the bulk of the production consists of lighter vehicles and acceptably light pedal efforts are obtained without the need for boosters. Thus it can be stated that the pedal effort is not a problem in braking today for normal brake usage.

From the foregoing, it can be seen that the braking problem today must be mainly the ability of the brake to deal with high energy absorptions, and while some improvement to braking has been made by the provision of wider brakes giving larger lining areas, it is probably true that no major contribution to braking has been made on American vehicles since the war. This is not completely the case with European produced vehicles where braking conditions and requirements are generally much more arduous than those in America. It is generally the custom to provide a larger area of lining per lb. of gross vehicle weight, than is the case with American vehicles and the test specifications which most European vehicles have to meet are in many cases more arduous than those required of the American brake. This is because it is common to take a fade test in the U.S.A. as 12 stops from 60 m.p.h. at 0·4 mile intervals and ½g deceleration, while we take 12 stops from 70 m.p.h. or even 80 m.p.h. at 1 mile intervals and ½g deceleration.

There is one fundamental difference between the approach to braking in Europe and in the United states; this is that generally vehicles produced in Europe do not employ brakes with a high self-energising factor. The basic brake specification for Europe consists of either a two leading shoe front brake and a leading and trailing shoe rear brake, or of a leading and trailing shoe front and rear brake. Most American vehicles use a self-energising type of brake, both front and rear in which the secondary shoe is energised by the primary shoe. The typical brake factors of these different brakes are as follows:

$$\text{Where brake factor} = \frac{\text{Drum drag}}{\text{Shoe Tip Effort}} = C$$

(*a*) Two Leading shoe $C = 2$
(*b*) Leading and Trailing Shoe $C = 1{\cdot}15$
(*c*) Self-energising Brake $C = 5$

The figure quoted for the self-energising type of brake as used in America is a typical one and can be modified by using different grades of lining on the primary and secondary shoes with the objects of either equalizing lining wear or increasing fade resistance by putting a lower co-efficient, high fade resistance lining on the secondary shoe. It should also be stated that if the two leading shoe and servo brakes are compared for torque assuming the same shoe centre lift for both brakes and the same pedal travel and pedal effort, then the ratio of torque is 2 for the two leading shoe to 3 for the servo type brake (approximately).

However, although by suitable design and choice of linings it is possible to reduce the servo effect and thus the power of the self-energising type of brake, it still remains that the change in torque for a given change in co-efficient of friction will always be greater on the self-energising type of brake than on the two leading shoe type, since this is inherent in the design of the brake. If it be admitted that the inability to dissipate energy at a high rate, which is generally termed brake fade, is the main problem in braking today, then it seems to the writer that the basic approach to this problem should be to adopt a brake which has fundamentally the minimum change of torque for a given change in co-efficient of friction.

Brake stability

It is interesting and also strange that whereas no British Manufacturer to the writer's knowledge has held up American braking of the automobile as a standard to be desired, it is general amongst British Manufacturers and users all over the world to hold up American truck braking as a high standard. This is significant, because a large number of American trucks use either fixed cam or two leading shoe brakes and the self-energising type of brake is not in wide use on heavy trucks. This seems to prove that if you want consistent braking and absence of fade, then a low self-energising factor should be adopted.

It is the writer's opinion that providing the pedal effort is sufficiently light then the main requirement which the brake has to meet is consistency. It must not pull to the left or the right; it must not become "grabby" or "touchy" and the pedal effort for a given deceleration must be consistent. These conditions are of course quite easy to meet if a lining is available with a co-efficient of friction which is absolutely consistent against temperature. Unfortunately no such brake linings exist at an economic price.

It is also the writer's opinion that a slight fall off in co-efficient of friction against rise in temperature is acceptable, and indeed desirable, but a rise in co-efficient with a rise in temperature is to be avoided. The reason that a fall in co-efficient of friction is stated to be desirable, is because this can give some indication that the brakes are being heavily used and since the pedal effort would become heavier it would tend to restrict the use of the brakes.

Shoe geometry in relation to lining co-efficient

The reason that a rise in co-efficient of friction is detrimental, is because the brakes tend to become erratic and "grabby" and also as is well known, in designing a brake it is desirable to put the lining in the best position for power and maximum utilization of the available volume of the lining. This is in order to give the maximum lining life and to spread the load more evenly over the lining area, so as to avoid concentrated peak loadings and reduce fade. Also if sliding

* *From a paper presented before the SAE at Detroit.*
† *Director and Chief Engineer, Girling Limited.*

shoes are employed which can centralize themselves in the brake drum the optimum position for the lining has to be determined with reference to the co-efficient of friction and the wear pattern is altered with maximum wear moving towards the heel or toe of the shoe as the co-efficient of friction either rises or falls.

If the lining position for a given co-efficient of friction is chosen to give a reasonable compromise on power, taking into account the maximum co-efficient of friction at which self-locking would occur, then it is desirable that this co-efficient of friction should not be exceeded and if allowance for a large percentage increase in co-efficient of friction has to be made to cover the brake when it is hot, then the performance at normal temperatures has to be sacrificed. With regard to brakes which become erratic when hot, it is interesting to observe that the locking angle of the leading edge of the lining of many brakes closely approaches the friction angle of the lining and study of the trailing end of the lining shows that the locking angle is often within this figure. This means that in the forward direction a moderate rise in co-efficient of friction would give a locking or grabbing brake and in reverse the tendency would be worse. In order to avoid this tendency it is necessary to avoid long lining arcs in most brakes, or if long arcs are used to employ low co-efficient linings of good stability. We have found it to be good practice to arrange the length of the lining and position such that the tangent of the locking angle of the leading and trailing ends of the lining is greater than the co-efficient of friction of the lining and this infers arcs of 90–100 deg.

Two trailing shoe brakes

Admittedly if brakes with a low self-energising factor are adopted the external power to the brakes has to be increased and prior to the introduction of vacuum boosters it would not have been possible to brake cars at the rates existing today with acceptably light pedal pressures, purely with the driver's effort and taking into account female drivers.

However, the introduction of vacuum boosters has solved this problem, and it is considered feasible today to use a brake of lower self-energising factor with a larger booster, thus to obtain extremely consistent results. The pedal efforts of course can be made whatever is desired by choosing the correct area of booster cylinder.

In essence the two trailing shoe brake is a two leading shoe brake run in reverse. There is, therefore, an anti-servo effect and the brake factor is reduced. In detail it consists of two shoes each operated by a hydraulic cylinder and the shoes are conformable by having the web depths reduced to a certain pattern. The brake is self-adjusting on the hydrostatic principle, the hydraulic pistons following out the shoes as the lining wears and the volume being made up by hydraulic fluid from the reservoir, there being no trapped line pressure. Frictional anti-shake back devices are used on each shoe to restrain them from vibrating away from the drum.

Brake size and horsepower absorptions

As mentioned above it is the tendency in Europe to use larger brake areas for a given vehicle weight, than is the case in the United States and the figures in the accompanying Table make a comparison between common practice on European vehicles and practice in America today:

These figures show:

Considering front brakes only

(*a*) Although the mean horsepower absorption figures for both American and British cars are approximately equal, the horsepower absorption figures for the secondary shoe on American brakes is approximately 3·42 average while that of the British vehicles is 2·45 average per shoe.

(*b*) The horsepower absorption per in^2 of drum area is lower on the British cars.

(*c*) On the faster and heavier British cars two trailing shoe brakes are used and horsepower figures are higher as short lining arcs are used.

Considering rear brakes only

(*a*) American cars tend to use smaller rear than front brakes in proportion to the weight and braking distribution.

(*b*) The secondary shoe horsepower absorption per in^2 of lining is on average considerably above that of the leading shoe of the British vehicle (3·33 to 2·355).

(*c*) The horsepower absorption per in^2 of swept drum area is approximately 40/50 per cent greater on American vehicles.

COMPARATIVE H.P. ABSORPTIONS

Vehicle	G.V.W. lb	Braking Ratio F/R	H.P. Absorption in² Lining: Front Mean	Front P.S.	Front S.S.	Rear Mean	Rear P.S.	Rear S.S.	Speed M.P.H.	H.P. Absorption per in² Drum Swept Area: Front	Rear	
A	4342	55·8/44·2	2·43	1·39	3·24	2·46	1·4	3·28	90	1·48	1·5	AMERICAN
B	3830	55·8/44·2	2·66	1·5	3·58	2·42	1·36	3·26	90	1·62	1·46	AMERICAN
C	3871	62·2/37·8	2·32	1·16	3·26	1·84	0·97	2·77	90	1·61	1·26	AMERICAN
D	5235	53/47	2·72	1·56	3·62	3·01	1·72	4·0	90	1·67	1·87	AMERICAN
A	3600	66·8/33·2	2·3			2·3 L/s			90	1·21	0·8	BRITISH
B	3388	65/35	2·42			1·95 L/s			90	1·48	0·8	BRITISH
C	4100	58/42	2·83			2·69 L/s			90	1·47	1·06	BRITISH
D	4462	58/42	3·02			3·12 L/s			90	1·58	1·15	BRITISH
E	3059	65/35	1·88			2·16 L/s			70	1·14	0·88	BRITISH
F	2800	65/35	2·24			1·92 L/s			65	1·39	0·75	BRITISH

In calculating H.P. figures on duo-servo brakes it has been assumed that work done by primary shoe to secondary shoe is in the ratio of 1 to 3. All figures based on 28 ft/sec/sec deceleration.

(*d*) It is possible satisfactorily to use higher horsepower figures for the leading shoe, providing the horsepower dissipation figures for the drum are kept round 1–1·2 per in^2.

The question, therefore, arises as to what is the correct area of brake to be used for a given duty. It is the practice of my Company to assess the mean horsepower loading per sq in of lining from a vehicle speed slightly below the maximum given speed of the vehicle and for a deceleration of 28 ft sec^2. We normally take a speed of 0·9 approximately of the maximum speed of the vehicle and this is chosen bearing in mind the price range of the brake and the deceleration to be accepted, and we attempt to limit the mean horsepower absorption to a maximum of 2·5 per in^2. It is not considered practical to take decelerations from the maximum speed of the vehicle, since taking into account wind resistance and time lag the brakes cannot be applied at the maximum speed. In the case of the two leading shoe or two trailing shoe brakes, this absorption is the same for both shoes but in the case of the rear brake where leading and trailing shoes are employed we consider the horsepower absorption on the leading shoe only.

Experience has shown that with the quality of linings which are available today, if 2·5 horsepower per in^2 of lining is not exceeded, fade is not usually a problem with the normal amount of cooling which is present. If, however, fade should be a problem with two leading shoe brakes then two trailing shoe brakes are employed. We normally use 110 deg lining arc, but recent work on high speed cars has shown that an 85 deg lining arc gives improved fade resistance and although the horsepower absorption per sq in of lining has increased in the ratio to the decrease in lining arc, stability has been improved.

The characteristic of judder or high speed vibration which is sometimes experienced when brakes are applied from high speeds with a high deceleration has also been considerably improved, by reaching the lining arc, and it has been found that by making the shoe web conformable in a certain pattern which has to be carefully determined, the high speed vibration is eliminated or very much reduced. It appears that making the shoe web conformable to this pattern permits the lining to spread the work equally over its whole area, and this eliminates blue spotting. Advantage is also obtained from the fact that a larger arc of the drum is left uncovered with the shorter linings and permits better heat dissipation. We have also found that the decrease in lining arc and, therefore, volume has not materially reduced the lining life under these conditions.

Disc brakes

Much interest is being displayed at the present in disc brakes and all manufacturers are seeking a satisfactory solution to the disc brake problem. My own Company has been involved in the development of disc brakes for some time and has experienced a considerable amount of success with these brakes in racing. We also have the first passenger carrying bus in the world to go in production with these brakes; this is operating very satisfactorily and the lining life is better than that experienced with drum brakes

It is interesting to compare the characteristics of the disc brake with those of the two trailing shoe brake. I have chosen the two trailing shoe brake because from the fade and stability point of view it is the best drum brake produced and, therefore, I think it is not worth while comparing the disc brake with any other design than this. The brake factor of the two trailing shoe brake for a co-efficient of friction of 0·38 is 0·59 and let us assume a pedal effort of 100 lb. If the co-efficient of friction falls to 0·25 the brake factor becomes 0·45, i.e. 24 per cent change and the pedal effort would rise to 131 lb; the percentage change of pedal effort is therefore 31. Under the same conditions the two leading shoe brake factor changes from 1·75 to 0·98, that is 44 per cent and the pedal effort rises to 179 lb, i.e. 79 per cent increase. The servo brake has a still greater change. The disc brake has no servo factor but is a Girling construction using a hydraulic cylinder applying a pad on each side of the disc.

The brake factor is equivalent to the co-efficient of friction which is therefore 0·38 in the case of a co-efficient of friction of 0·38 and becomes 0·25 if the co-efficient of friction drops to 0·25, and the pedal effort changes from 100 lb to 152 lb. This is a percentage change in the brake factor of 34·4 per cent and 52 per cent increase in the pedal effort. Therefore, purely on theoretical grounds the two trailing shoe brake is less fade conscious than the disc brake; this is not substantiated in practice because of the different construction of the two units.

On the two trailing shoe brake the heat has to be conducted away through the drum, while on the disc brake the heat is mainly dissipated to the atmosphere; also the uncovered area of the disc is greater than the uncovered area of the drum brake and, therefore, dissipation is better on the disc brakes. However, it would seem from the theoretical figures that a fade resistance comparable with the fade resistance of the disc brake can be achieved on the two trailing shoe design. The disc brake of course scores from the point of view of smoothness because there is no change in the shape of the disc, whereas the brake drum shape changes when being subjected to shoe pressures at high temperatures, and of course the disc brake does not expand away from the linings as is the case of the shoe brake. On the contrary the disc expands towards the linings.

Although the theoretical brake factor of the disc brake is lower than that of the two trailing shoe brake, this can be compensated for by the fact that a high overall ratio of the hydraulic system can be used with the disc brakes, owing to the fact that linings can run at very small or no clearance from the disc and the disc expands towards the linings. The Girling design uses the hydrostatic principle of automatic adjustment mentioned above.

On the drum brake the overall ratio which can be employed is limited by the ability to follow up a hot drum. Even if an automatic adjuster is used in the two trailing shoe brake it is still necessary to provide sufficient shoe centre movement in order to follow up the growth of the drum during one maximum stop, although adjustment would immediately take place when the foot is removed from the brake pedal.

Comparison of the figures for horsepower absorption for the disc and drum brakes is interesting. For the disc brake we employ a segmental lining and use a horsepower absorption figure of 6·5 to 7·5 per in^2 of lining. The horsepower dissipation for the disc is 0·65–0·75 per in^2. Thus while the lining loading has gone up by approximately three times as compared with the drum brake the dissipation rate has been almost halved per sq. in of swept area of disc compared with the drum. Although, based on these figures, it will be seen that the lining area of the disc brake has been reduced in the ratio of 3 : 1 the total volume of lining available for wear on the disc brake exceeds that of the comparable drum brake by some 10–15 per cent because the whole of the lining volume can be worn away, while on the drum brakes the ends of the lining arc are usually left thicker than the middle portion of the arc.

Finally I would like to sound a note of warning regarding the ability of the disc brake to rescue designers from the difficulty of the small wheel. The disc brake, in order to give satisfactory life must be chosen of adequate size and in its present state of development offers no universal panacea for designers' space problems.

*'Syndromic'
Automatic Lubrication soon pays for itself!

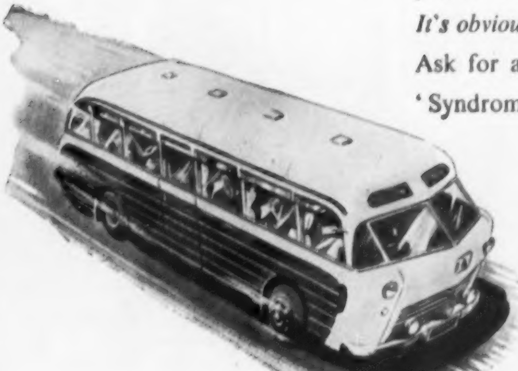
*INCREASES YOUR PAYLOADS 10%

From the moment you equip your vehicle with 'Syndromic' Lubrication it begins to pay for itself! First, it saves up to 75% on lubrication costs. Then, it ensures less wear on bearings because it automatically lubricates up to 80 bearings (using 2 pumps) at periods controlled by mileage. As a result, maintenance and replacement time and costs are kept down to a minimum.

But besides all that, 'Syndromic' lubrication saves the hours spent in the service bay. *It lubricates while the vehicle is working*, allowing you to increase your vehicles' payloads by as much as 10%!

It's obvious that 'Syndromic' lubrication soon pays for itself!

Ask for a Tecalemit technical representative to call and discuss the 'Syndromic' system with you.



TECALEMIT

The Authority on Lubrication

PLYMOUTH, ENGLAND

T416

The *NEW* BESCO Production Universal SWAGING WIRING & JENNYING MACHINE

is a Winner

IMMEDIATE DELIVERY

● **Remarkable for its strength of construction— unequalled in this field of machinery**

ALL STEEL** construction – **UNBREAKABLE

This machine, **Model E/14,** handles Flat Sheets, Discs, Cylinders and Drums up to 14-gauge mild steel; other metals in proportion. Covers most rotary forming operations met with.
12 pairs of standard wheels supplied; special wheels available if required. Of heavy gauge welded-steel plate construction for operations on m.s. sheets up to 14 S.W.G. Fitted with special gauge for working narrow strips as well as large cylinders and sheets, adjustable for working up to edge of metal. Depth of gap to gauge 14½ in.; Frame to end of spindles 17¾ in.; working centres of spindles 4 in.; length of spindle available for rollers and diameter 1⅜ in. × 2⅜ in. Motor drive.

International **MACHINE TOOL** *Exhibition*
OLYMPIA June 22 July 6
STAND Nº 214
● **EMPIRE HALL** *Ground Floor*

F.J. Edwards Ltd

Edwards House, 359-361 Euston Road, London, N.W.1
Phones: EUSton 4681 (7 lines) 3771 (4 lines). *Grams:* Bescotools Norwest London

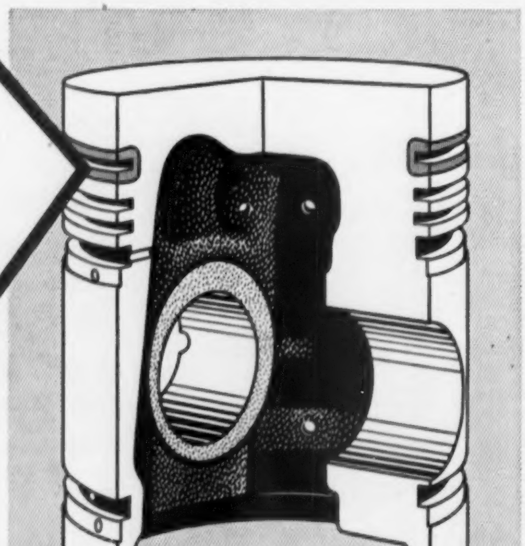
Lansdowne House, 41 Water Street, Birmingham, 3
Phones: CENtral 7606-7. *Grams:* Bescotools Birmingham 3

WELLWORTHY AL-FIN
armoured ring groove
LONG LIFE PISTONS

more than pay for themselves in the first year . . . . BECAUSE

The average life of an Al-Fin Piston is at least 100% more than normal types. This double mileage saves you the cost of one overhaul *and* the cost of another set of pistons. To this can be added the further saving effected by keeping the vehicle on the road during the whole period. No wonder so many large fleet owners say:—

AL-FIN is the best investment yet



An Al-Fin armoured ring groove piston. The top ring groove has an austenitic cast iron insert bonded *to the alloy giving strength where it is required, prolonging piston life by at least 100%.*

WELLWORTHY
AL FIN

'The Choice of the Expert'

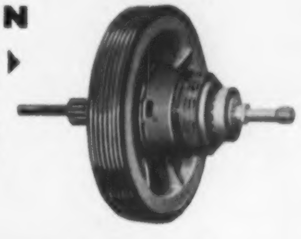
BONDED INSERT PISTONS WELLWORTHY LIMITED, LYMINGTON, HANTS

For the most efficient performance...

...IN POWER TRANSMISSION

HIGH SPEED MULTIPLE DISC CLUTCHES

This design is particularly suitable for machine tool drives and for other machinery running at high speed. The clutch is very powerful for its size; it has a clean contour and it incorporates a compensating feature which eliminates frequent adjustment.



PNEUMATIC CLUTCH-BRAKE ASSEMBLIES

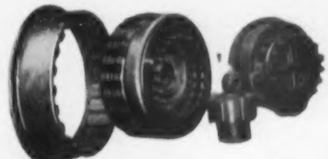
Suitable for presses, shearing machines, expanding and contracting machines, forging machines and all heavy duty drives of frequent operations.

FLEXIBLE COUPLINGS

This Elliptical Rubber Buffer Flexible Coupling is extremely efficient. The two shafts are free to move axially and the shape and flexibility of the Rubber Buffers ensure that even pressure is exerted by each Driving Lug. Suitable for either direction of rotation.

POWER TAKE-OFF CLUTCH ASSEMBLIES

Complete self-contained units for Diesel and Petro engines to drive all kinds of machinery. Range of sizes to suit medium and large powers and speeds.



CLUTCH-BRAKE ASSEMBLIES

The illustration shows a pneumatic Clutch-brake Assembly supplied for a 500 ton Forging machine. Duty 1,100 h.p. at 42 r.p.m. frequency 3-4 strokes per minute.

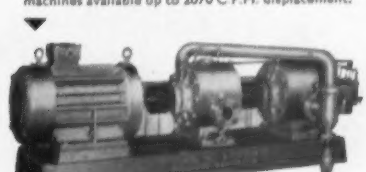
...AND AIR/GAS HANDLING PLANT

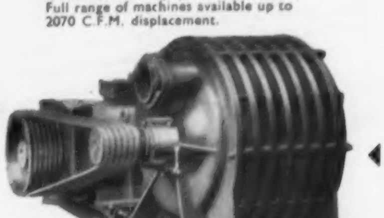
ROTARY AIR COMPRESSORS

Two Stage Rotary Compressors having a free air capacity of 1000 C.F.M. at 100 lb/sq. inch pressure. Full range of machines available up to 2070 C.F.M. displacement.

ROTARY VACUUM PUMPS

Two Stage Rotary Vacuum Pump. 290 C.F.M. displacement, 29.98 inches H.C. Full range of machines available up to 2070 C.F.M. displacement.





TURBO BLOWERS AND EXHAUSTERS

Range available up to 7½ lb/sq. inch pressure and 10 inches of Mercury Vacuum.

Whittaker Hall

WHITTAKER HALL & CO. (1929) LIMITED

(Sole proprietors of R. S. Wittig & Co. (Compressors) Ltd.)

WH

RADCLIFFE, LANCASHIRE

'Phone: Radcliffe 2421-2 'Grams: Clutch, Radcliffe, Manchester

London Office: 119, VICTORIA STREET, S.W.1 'Phone: Victoria 2612,

Equip with KING DICK, the ALL-BRITISH Hand Tools with the unmistakable stamp of quality, precision engineering and the finest finish. For YOUR particular job you'll do well to specify the very best . . . and there are none better than British Made KING DICK Hand Tools.

BUY BRITISH

Please write to Dept. A.E. for your copy of our 80-page catalogue.

ABINGDON

KING DICK

ABINGDON WORKS · KINGS RD · TYSELEY · BIRMINGHAM 11 · ENGLAND

R/E157

CASTINGS

in

GREY IRON WHITEHEART MALLEABLE

or

NON-FERROUS METALS

•

GEORGE WEARING LTD

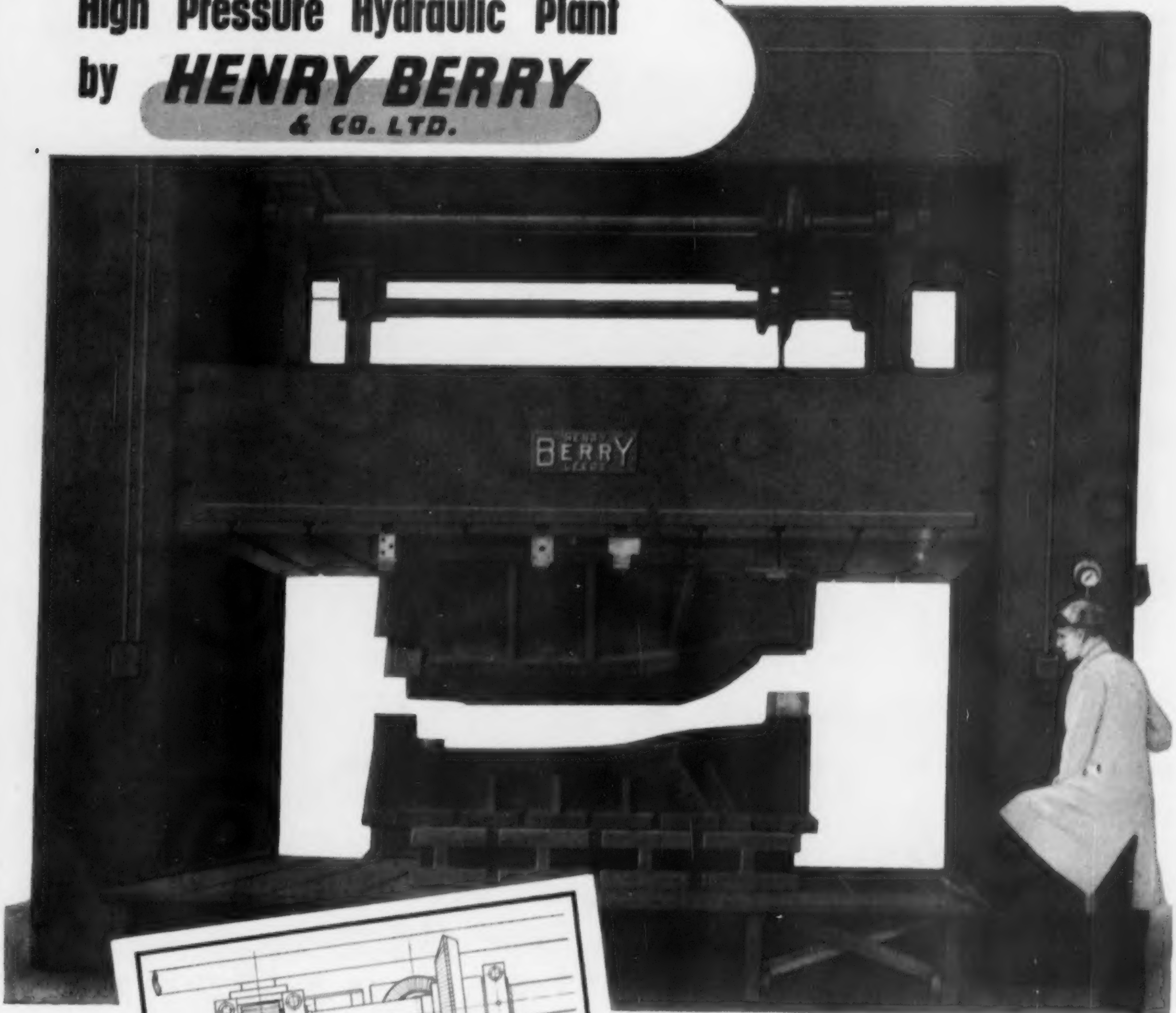
CARTERS GREEN FOUNDRY
WEST BROMWICH

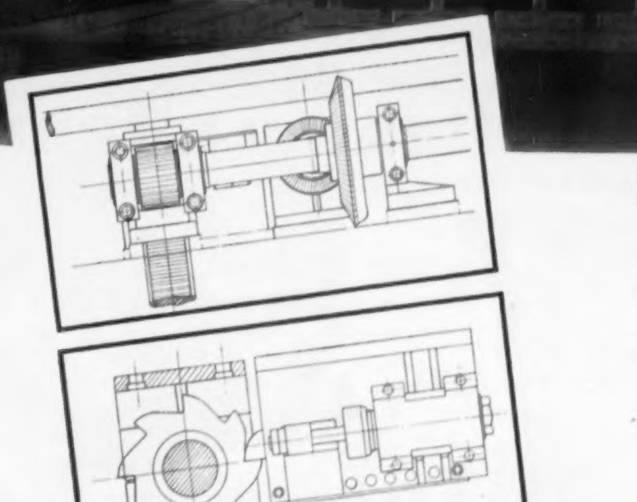
TEL: WEST BROMWICH 0092
TELEGRAMS: "WEARING" WEST BROMWICH

ESTABLISHED 1850

SPECIALISTS IN THE PRODUCTION OF SMALL REPETITION GREY IRON CASTINGS

High Pressure Hydraulic Plant by HENRY BERRY & CO. LTD.





HYDRAULICALLY OPERATED DIE SPOTTING PRESS

The Spotting Press illustrated above is extensively used in the Automobile Industry for final finishing of large pressing dies.

The 12 ft. × 7 ft. table is fitted with Equalizing Gear to ensure accurate alignment.

We manufacture

Hydraulic presses for a wide range of processes up to 5,000 tons, and matching ancillary equipment (Pumps, valves, accumulators, etc.).

Heavy mechanical workshop tools, plate bending rolls, shears, calenders and railway workshop tools.

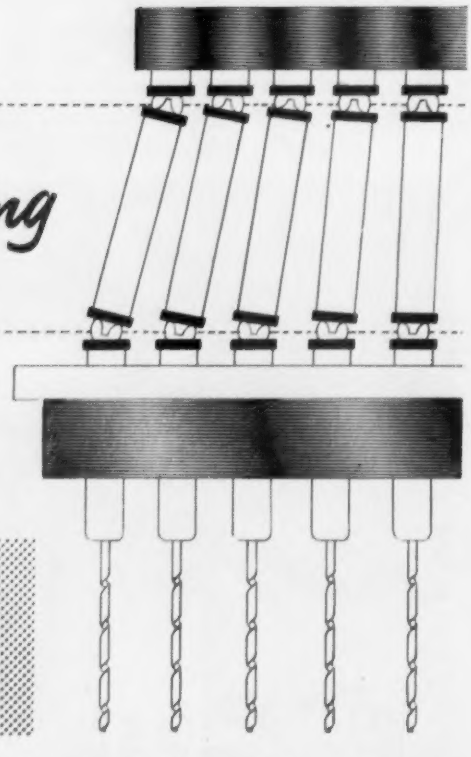
Also many special designs of tools for industry, such as Continuous Finishing Presses for Rayon and Silk, Veneer and Plywood Presses, etc.

HENRY BERRY & CO. LTD.

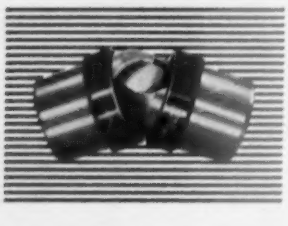
CROYDON WORKS, LEEDS 10, ENGLAND.

Telephone: Leeds 75481-2 Telegrams: RIVETTER LEEDS 10.

High load carrying



(ME) and Hooke's Type Universal Joints have a place in every industry. They are precision made to combine high load carrying capacity with constant reliability over long periods of service. Why not write for details today ?



MOLLART ENGINEERING COMPANY LTD

KINGSTON BY-PASS · SURBITON · SURREY · TELEPHONE ELMBRIDGE 0033-7 · TELEGRAMS PRECISION SURBITON

1442

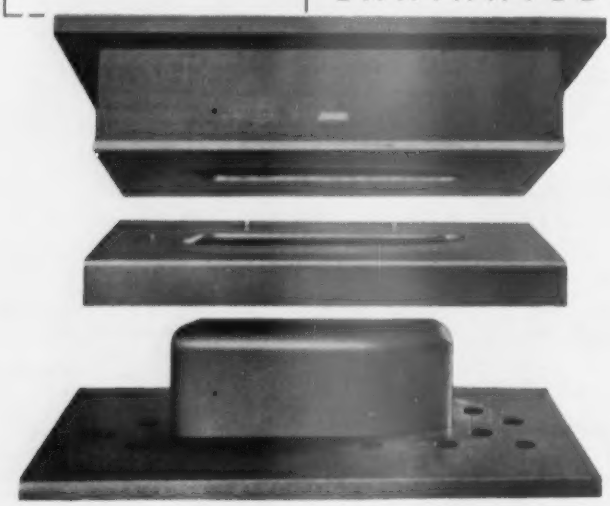
Illustration shows Hy-du-lignum Raising Tool for mild steel petrol tank pressings.

Photograph by courtesy of Weathershields Ltd.

Mechanical press tool designers naturally prefer—

Hy-du-lignum & Jabroc

LAMINATED COMPRESSED WOOD



- One-fifth the weight of steel.
- Low cost. • Speedy manufacture.
- Supplied as finished tools or as board.

Please write for illustrated brochure SL/8 to:

HYDULIGNUM-JABROC (TOOLS) LTD.

Associated with Hordern-Richmond (Sales) Ltd.

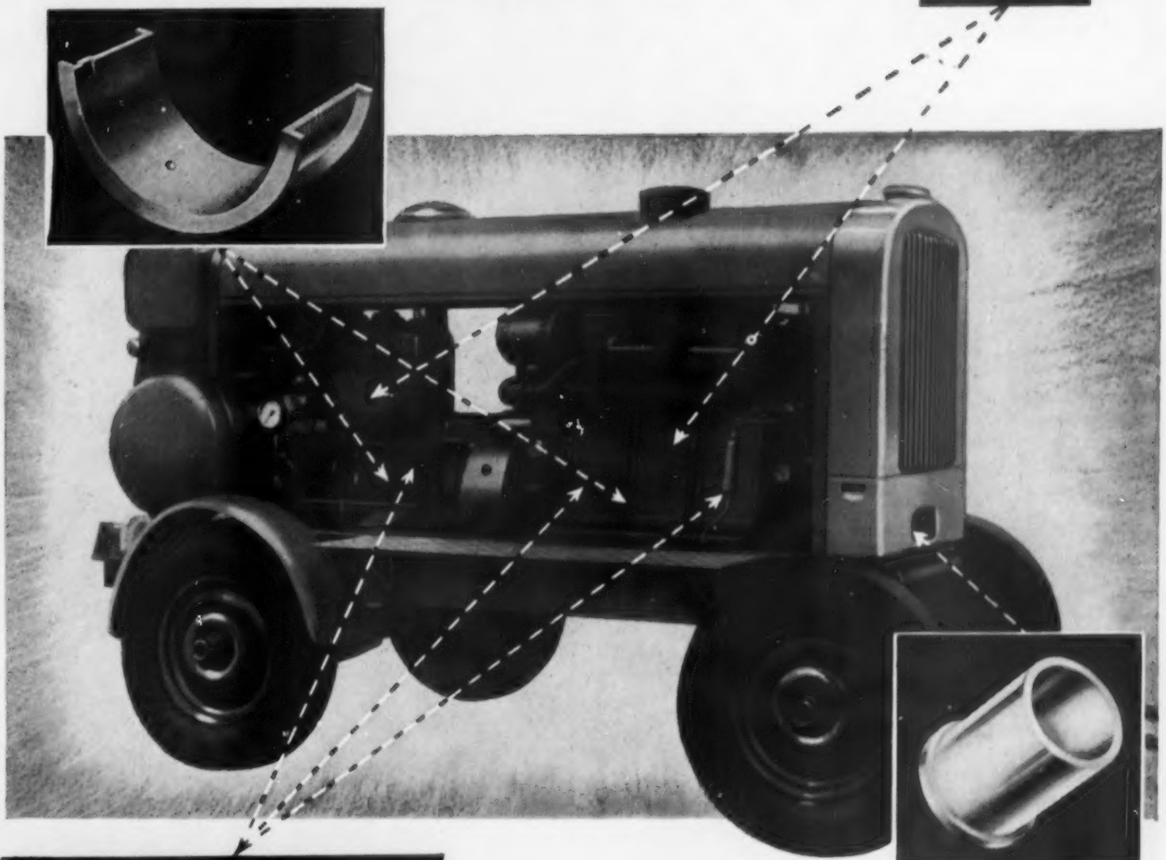
Designers and manufacturers of jigs and tools in Hy-du-lignum · Jabroc · Steel · Hyroc (paper based laminate) · Glass Fibre.

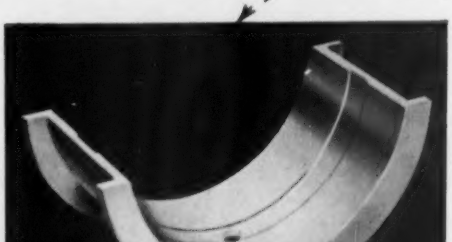
Head Office: Hy-du-lignum Works, Haddenham Bucks. *Tel.*: Aylesbury 1100-1102. *Grams.*: Winstix, Aylesbury

Northern Office: 89 Oxford Street, Manchester, 1. *Tel.:* Central 9364/5/6

Jig and Tool Works: Mill Lane, Waddon, Croydon. *Tel.*: Croydon 2201

Used to Neglect ...





This twin cylinder diesel compressor set will have to work at full pressure for long periods, under arduous conditions and with very little attention. The accuracy and strength of BIRSO non-ferrous castings are relied on to give unfailing service, year in, year out. Illustrated are some of the BIRSO phosphor-bronze castings used in the set, ranging from main bearing shells to connecting rod and starting-handle bushes. They are all cast to the same exacting specifications and precision-machined in our own extensive machine shops.

Our great experience and unrivalled resources, coupled with a *personal* service, are available to help solve *your* problems, too.

Castings from a few ounces to 10 tons in phosphor-bronze, gun-metal, aluminium-bronze, manganese-bronze and light alloys. Precision-machined bushes and bearings. Specialists in high-tensile aluminium-bronze castings, centrifugal-cast wheel blanks, and chill-cast rods and tubes.

BIRSO
TRADE MARK
BN

T. M. BIRKETT, BILLINGTON & NEWTON LTD.

HANLEY AND LONGPORT, STOKE-ON-TRENT

Head Office: HANLEY, STOKE-ON-TRENT *Phone: Stoke-on-Trent* 22184/5/6/7. LONGPORT *Phone: Stoke-on-Trent* 87303

One of Britain's Largest NON-FERROUS Foundries

Where's that washer?..

With G K N Sems Fasteners there's no fumbling, no time wasted in putting washer and screw together by hand. Sems are supplied complete with the right-size, right-type of washer already captive around the collar of the screw. The washers can't fall off, can't be mislaid or missed out. Vibration-proof Sems make firmer fastenings, they mean easier handling, speedier assembly and simpler ordering and stock control. They are available with spring, toothed or flat washers in a wide variety of sizes.

If it's a matter how to fasten one thing to another, get it touch with GKN

GUEST KEEN & NETTLEFOLDS (MIDLANDS) LIMITED · *Screw Division: Box 24, Heath Street, Birmingham 18*

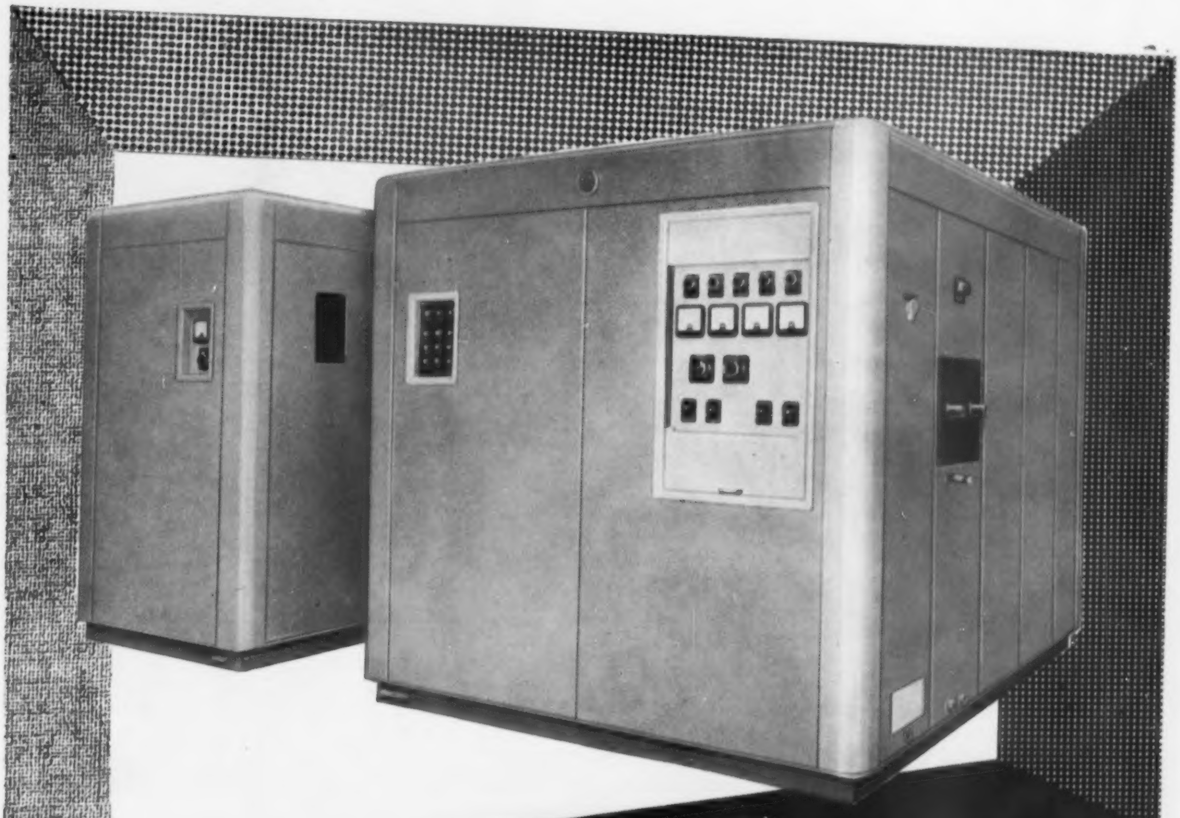
Literally—a hairsbreadth

Today, most progressive engineers think of Coopers Felt as an engineering material, yet many do not know that it can be machined to close limits. With the harder felts we can work to within a hairsbreadth of your specification. Yes, we mean that literally—to the breadth of a human hair. One of Cooper's technical advisers will be happy to tell you more about this versatile material.

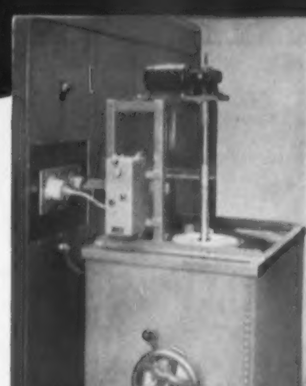
COOPERS FELT

COOPER & CO. (B'HAM) LTD.
BRYNMAWR - BRECONSHIRE

Telephone: Brynmawr 312



The world's most powerful AIR COOLED R.F. INDUCTION HEATER



Heating a spur wheel for a tractor gearbox before hardening in the special Redifon quench bath.

This new 125 kW heater has been specially designed to give reliable and continuous performance under the most arduous industrial conditions. Its efficiency is unimpaired by widely-varying electrical loads or poorly regulated mains supply. And the IH.45 is air cooled . . . an economy feature no other R.F. generator of this output has ever had. Typical amongst many possible applications are one shot hardening of gears . . . hardening crankshafts, sprockets and motor car cylinder walls . . . rapid melting of Nimonic alloys . . . hardening teeth of main transmission gears for lorries . . . and tube welding. The Redifon IH.45 speeds production by reducing processing time to an absolute minimum, and is so simple to operate that it can be used by unskilled personnel.

Industrial Electronics Division

REDIFON LIMITED, BROOMHILL ROAD, LONDON, S.W.18. VANdyke 7281

A Manufacturing Company in the Rediffusion Group


AUSTIN
USE
CLANCEY
CAST-IRON
VALVE GUIDES & CHILLED FACE TAPPETS
SUPPLIED AS CASTINGS OR FULLY MACHINED
The New AUSTIN SEVEN
G·CLANCEY LTD · BELLE VALE · HALESOWEN
TELEPHONE CRADLEY HEATH 69411-2-3


Magnetic Chucks
IN STANDARD SIZES OR TO YOUR OWN SPECIFICATION
Our catalogue will help you select a type and size of chuck most suitable to your own needs.
Write for your copy today.
J. H. HUMPHREYS & SONS, LTD., BLACKRIDING ELECTRICAL WORKS, WERNETH, OLDHAM. PHONE: MAI 1651

bumper crop of keys

Why should ignition keys remind you of bumpers, front and back, with over-riders to taste ? Why should bumpers lead you irresistibly to door handles and window-regulators ? Why should handles make you think of radiator grilles, three-dimensional badges and the mechanism that holds up the lid of your boot until you close it again ? You pull out your golf bag and lock the boot . . . with a key . . . a Wilmot Breeden key.

From bumper to boot-lock, if you drive a modern British car it's well-nigh certain that Wilmot Breeden have contributed something useful to its usefulness. And when you consider the size of the British Automobile Industry, that suggests a certain amount of activity.

Next time your car key turns up in the right pocket . . . next time you see a road leading to Birmingham . . . next time your bumpers stand between you and a gatepost . . . say " Wilmot Breeden."

WILMOT BREEDEN ARE AT BIRMINGHAM : ALSO AT LONDON, MANCHESTER, GLASGOW, MELBOURNE, TORONTO

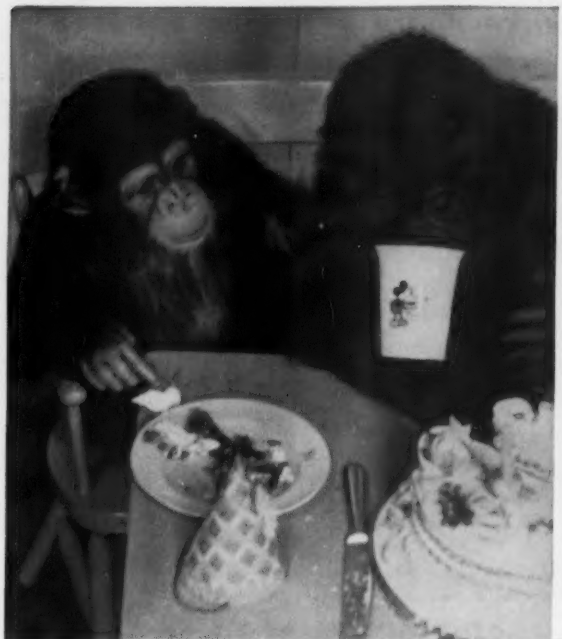
The finest all round degreasant and cleaner

FOR ALL METAL PARTS, MACHINERY, FLOORS, WALLS, PAINTWORK, TILES, ETC.

Grease and oily deposits don't stand a chance when GUNK gets to work! Simply brush or spray GUNK on wherever is to be cleaned — rinse off with water — and see how all traces of grease and oil are instantly removed. So simple to use and so effective! There is no bothersome heating or mixing either. GUNK is supplied ready for use in 5, 10 and 40/45 gallon drums.

Send today for a free trial tin and see for yourself the remarkable cleaning powers of GUNK.

Manufactured by BENNETT (HYDE) Ltd. · Boston Mills · Hyde · Cheshire Tel. Hyde 1377-8-9



but nothing compares with

Eclipse

the best hack saw blade

"Eclipse" hack saw blades, tool bits and other engineers tools are made by :
James Neill & Co. (Sheffield) Ltd. and are obtainable from your usual tool distributor

UH 2

In the words of Shakespeare:

" There is no other way "

"King Richard III." Act IV. Scene IV.

To Queen Elizabeth the only way for King Richard III to win her daughter was to tell the truth. By the same maxim we believe there is no other way to convince you of the efficiency of the 'POP' Riveting System, for "an honest tale speeds best being plainly told".

And speaking plainly, this modern and most efficient of riveting systems increases production, reduces labour costs and enables riveting to be done by one operator, in one operation, working from one side of the material only.

Our technicians will be pleased to advise you.

"POP" RIVETING
ONE OPERATOR OPERATION

Geo. **TUCKER EYELET** Co. Ltd.
Walsall Road · **BIRMINGHAM 22**
Telephone : BIRchfields 5024 (7 lines) Telegrams : EYELETS, BIRMINGHAM

Consultants & Tool Manufacturers :
AIRCRAFT MATERIALS LTD. Midland Road, London, N.W.1

"POP" is a regd. Trade Mark of Geo. Tucker Eyelet Co. Ltd.

'POP' RIVETS
REG'D TRADE MARK

THE MODERN SYSTEM OF RIVETING

Sellotape
BRAND

SIX STAR MASKING TAPE

★ **Extra Thin**
gives a sharp, clean outline by eliminating paint build-up.

★ **Highly Flexible**
takes the trickiest contours and corners with ease, without wrinkling.

★ **Extra Strong**
draws straight from the roll without tearing

★ **Gently Adhesive**
sticks at a touch to metal, plastic, glass, wood and rubber—and never curls back.

★ **Resists Penetration**
entirely unaffected by the heaviest spraying with paint dopes, lacquers, enamels and other liquids.

★ **Strips off Easily**
leaves surface completely unaffected after use.

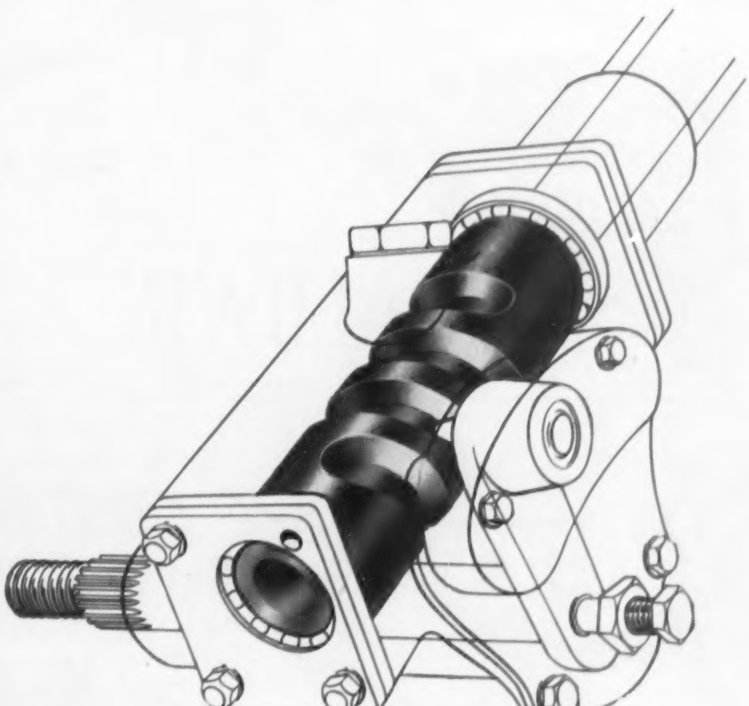
Marketed by **GORDON & GOTCH LTD**
Sellotape Division, 39-40 Farringdon Street, London, E.C.4 CENtral 0531

Sellotape is the Registered Trade Mark of Adhesive Tapes Ltd

G&G

PARK GATE

QUALITY STEELS FOR AUTOMOBILE ENGINEERING



1823 EXPERIENTIA DOCET 1956

special freecutting
casehardening
quality bars

THE PARK GATE IRON and STEEL COMPANY LIMITED ROTHERHAM

TELEPHONE ROTHERHAM 2141 (10 lines) TELEGRAMS: YORKSHIRE PARKGATE, YORKS

. . . a large range to choose from

BALDWIN PNEUMATICS enable you to choose from probably the largest range of pneumatic equipment in the country. No fewer than 336 standard types of double-acting air cylinders are available-at competitive prices and with prompt delivery. Baldwin air cylinders are ruggedly built and are thoroughly reliable in even the most arduous working conditions.

Baldwin pneumatics also manufacture a wide range of top quality control and pilot valves, and associated accessories which will adequately cover all your requirements.

Further details are included in Baldwin Brochure No. A1-503 available on request.

BALDWIN *Industrial Pneumatics* bP

BALDWIN INSTRUMENT COMPANY LTD., DARTFORD, KENT Telephone: 2946

Ward

Nº 2C CAPSTAN LATHE
For Maximum Production

Many new features include

- INBUILT ELECTRICAL EQUIPMENT
- 12 SPINDLE SPEEDS—BOTH FORWARD & REVERSE
- RAISED CENTRES GIVING INCREASED SWING
- LARGE CAPACITY SWARF PAN
- BED PROTECTED BY STAINLESS STEEL COVERS

All Ward Lathes are designed and built to get the best out of Tungsten-Carbide cutting tools

Please write for particulars of our full range of Capstan & Turret Lathes

1¼ IN. BAR CAPACITY
13¼ IN. SWING OVER BED

SELLY OAK 1131

H.W.WARD & CO. LTD SELLY OAK BIRMINGHAM 29

W606

INTERNATIONAL MACHINE TOOL EXHIBITION, LONDON 1956, JUNE 22 TO JULY 6—STAND 17, GRAND HALL, OLYMPIA.

CASTINGS TO CROW ABOUT

And you'll get them good and early from Gloucester

YOUR grey iron castings always come up to scratch when you get them from Gloucester Foundry. This is one of the most advanced foundries in Europe, supplying very large outputs of castings to the railways, the automobile industry, agricultural machinery makers, and many other leading engineering and allied industries. You get castings on time, consistent in quality, and keenly priced. Why not let Gloucester quote for your next castings in grey iron, 'Blackheart' malleable, or special alloy irons? A Gloucester casting specialist is always ready to call on you and advise on casting design to help save both time and money.

Give the job to

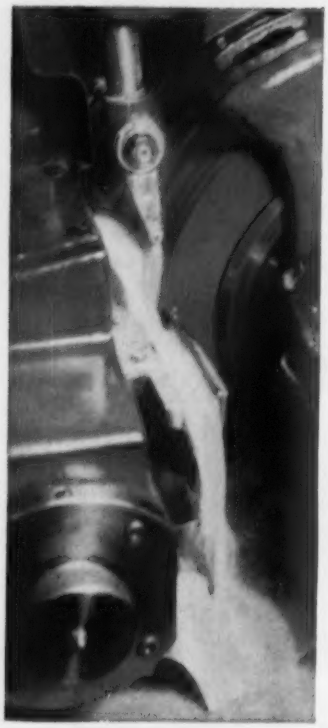
GLOUCESTER

GLOUCESTER FOUNDRY LTD., EMLYN WORKS, GLOUCESTER

(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)

Telephone: Gloucester 23041 *Telegrams: 'Pulleys' Gloucester*

GLOUCESTER
THE HOME OF
GOOD CASTINGS



Proper coolant control boosts production

Is it possible to make machine tools reproduce more accurately, cutting tools last longer and measurably improve surface finish simply by changing the cutting fluid? Emphatically Yes! These worthwhile results have been accomplished many times by one or other of the 46 products in the Fletcher Miller range.

More parts per honing stone:

One well-known firm of motor car manufacturers was micro-honing big-end bearing housings in EN.18c chromium steel connecting rods to an accuracy of 40 micro-inches. The previous cutting fluid gave 85 parts per set of honing stones but, by the introduction of Swift H, this was improved to over 2,000 parts—a 2250% increase!

Better Surface finish

Then there were the machine tool manufacturers who found when testing their precision surface grinder that it would fine grind tungsten carbide to a surface finish of 0.5 micro-inches—if Filedge were used in the coolant tank!

We could do as much for you. *Ask today for particulars of Fletcher Miller Cutting Fluids.*

SPECIFY **FLETCHER MILLER**

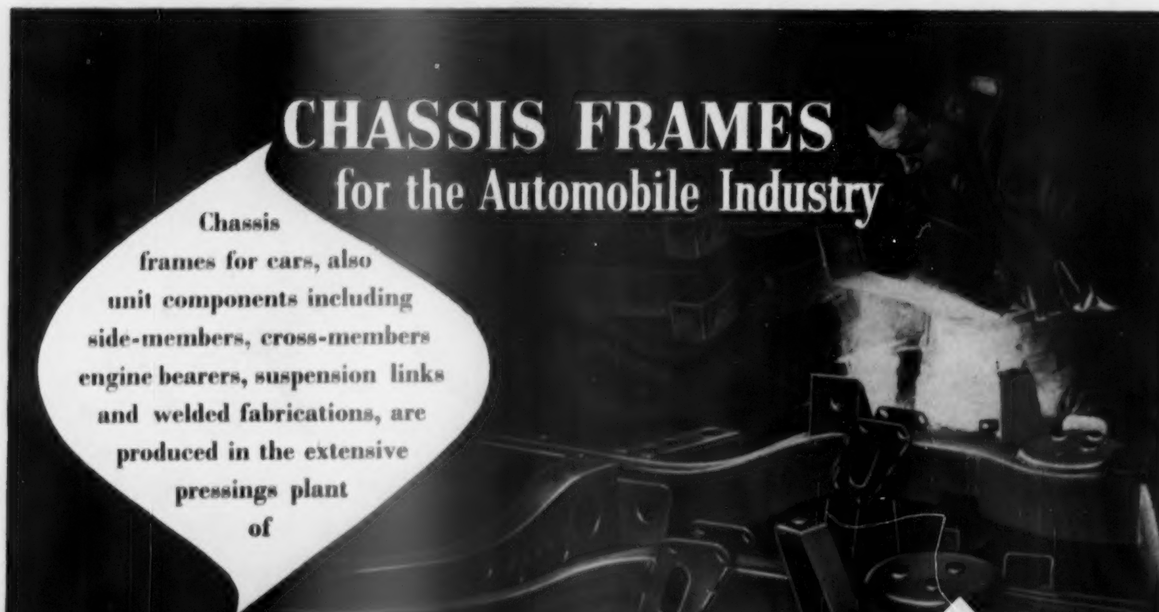
cutting fluids

See our Exhibit on Stand D510 at the B.I.F., Birmingham

—YOUR PARTNERS IN PRODUCTION

FLETCHER MILLER LTD · ALMA MILLS · HYDE · CHESHIRE

CF98



When **weight** is a problem

Come to think of it, weight nearly always *is* a problem.

In almost every branch of industry—and particularly in transport—weight saved means greater all-round efficiency and economy.

That's where light, strong and durable 'Kynal' wrought aluminium alloys come in—enabling weight to be reduced without loss of strength. With the aid of the Technical Service and Development staff of I.C.I. Metals Division, engineers and designers are constantly finding new uses for 'Kynal' alloys.

May we help solve *your* weighty problems?

'KYNAL' AND 'KYNALCORE' wrought aluminium alloys are already extensively used in the following industries:

Aircraft: *ribs, spars, engine components, stressed skin covering, fittings, etc.*

Railways: *structural members, roofing, panelling, windows, luggage racks, etc.*

Road Transport: *structural members, floor planks and panelling, windows, tread strips, doors, small fittings, etc.*

Shipbuilding: *bridges, wheelhouses, outer funnels, life-boats and davits, decks, skylights, stanchions, bulkheads, watertight doors, etc.*

Building: *roof coverings, side claddings, ventilators and windows, panelling, interior fittings, etc.*

'KYNAL' AND 'KYNALCORE' WROUGHT ALUMINIUM ALLOYS

ICI

M.414

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

Britain's Roman Highways

WATLING STREET

When the Romans invaded Britain they were faced with the problem of creating suitable highways which would give their legions access to the ends of the country. Of the many they built the most important and famous were the Four Ways, Watling Street, The Fosse, Ermine Street, and Icknield Street.

Watling Street ran from Dover to Wroxeter via Canterbury, Rochester, and London. It then continued Northwards in two sections to Carlisle and the vicinity of Newcastle. In its time this road has carried the march of history over Britain.

To-day the historic highway has become part of the main road transport system of the country. This system is about to be modernized so that the transport of the country may continue to flow evenly.

" Richard Berry have been actively concerned in improving the passage of vehicles over the roads of Britain and the World for over a hundred years. Today the tradition of their skilled craftsmen is being kept alive by the products of their new road spring factory.

write for your copy of

"LEAF SPRING DESIGN"

by Alan Hodgson

CARRY ON BERRY

RICHARD BERRY & SON, WEST BROMWICH, STAFFS.

Tel. West Bromwich 1766/7/8.

ONE OF THE BROCKHOUSE COMPANIES

it's all very well but...

When a pieceworker starts on 'ifs' and 'buts' about press guards, it is time you asked UDAL about the famous 'Fastrip' Synchronised Guards for *increased* production and *increased* safety. The 'Fastrip' is worked by compressed air and guard and clutch are synchronised to ensure split-second timing. Send for details today.

J. P. UDAL
LIMITED
INTERLOCK WORKS,
COURT ROAD,
BIRMINGHAM, 12
Telephone : CALthorpe 3114

Udal
PRESS GUARDS

Versatile —Powerful

—for heavy duty on a wide range of work

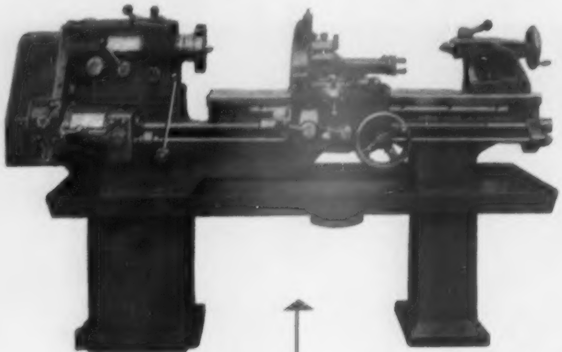
Archdale 34" VERTICAL

REVERSIBLE AUTOMATIC FEEDS AND QUICK POWER TRAVERSE IN THREE DIRECTIONS

The characteristic power and rigidity of the 34" Vertical Milling Machine is demonstrated to good effect when taking a $\frac{1}{4}$" cut at $3\frac{1}{2}$" per minute on this 4% carbon steel billet. This machine is installed at Geo. Swift & Sons Ltd., who find its great versatility invaluable in producing a wide range of machine tool components. All 12 feeds and spindle speeds are selected from the front of the machine, the speeds ranging from 29—520 or 36—638 R.P.M., and the feeds $\frac{3}{8}$" to 20" per minute.

JAMES ARCHDALE & CO., LTD.

BIRMINGHAM 16 · *SOLE SELLING AGENTS:* ALFRED HERBERT LTD. COVENTRY



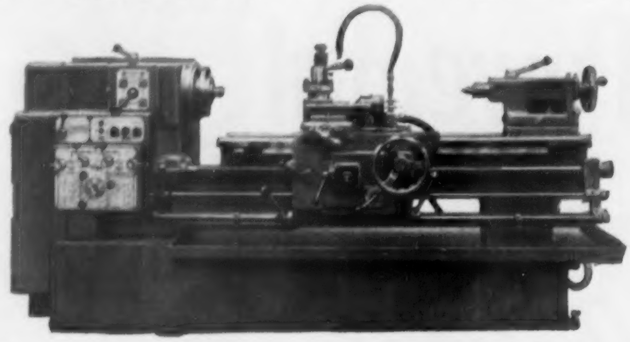
Woodhouse & Mitchell

'70' junior 7" centre lathe

'85' 8½" centre lathe

Proprietors : Thos. W. Ward Limited

WOODHOUSE & MITCHELL · Wakefield Rd. Brighouse. 'Phone 627



8 SPINDLE SPEEDS 30—874 r.p.m. Spindle mounted on selected taper roller bearings · Diagonally braced bed · Nickel steel gears on multi-splined shafts · Inverted vee and flat guides · Single lever selection of feeds · Tension mounted lead screw · Oil immersed multi plate clutch

12 SPINDLE SPEEDS 21—945 r.p.m. Rigid one piece fabricated steel base · Rapid spindle speed selection · Feed reverse control from apron · Totally enclosed auto lubricated quick change feed gear box.

Send for fully illustrated booklet.

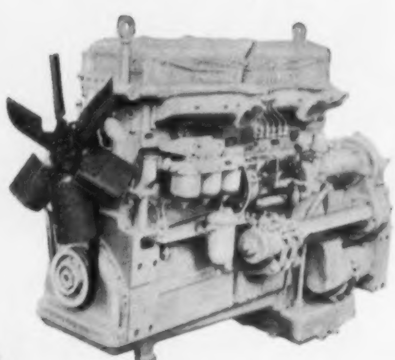
W.H.17.

Rathbone

VANDERVELL

BEARINGS & BUSHES

fitted to the MEADOWS 6 D.C. 970 6 CYLINDER ENGINE



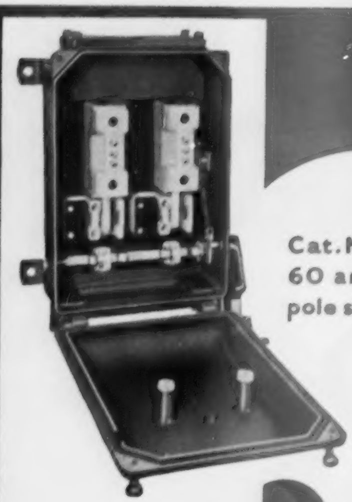
VANDERVELL LTD

The largest producers of bearings and bushes in Europe

VANDERVELL PRODUCTS LIMITED · WESTERN AVENUE · ACTON W3 LONDON

VANDERVELL PRODUCTS (CANADA) LIMITED

QUEEN ELIZABETH HIGHWAY AT 401 KIPLING AVENUE (HOLLYWOOD POST OFFICE) TORONTO CANADA



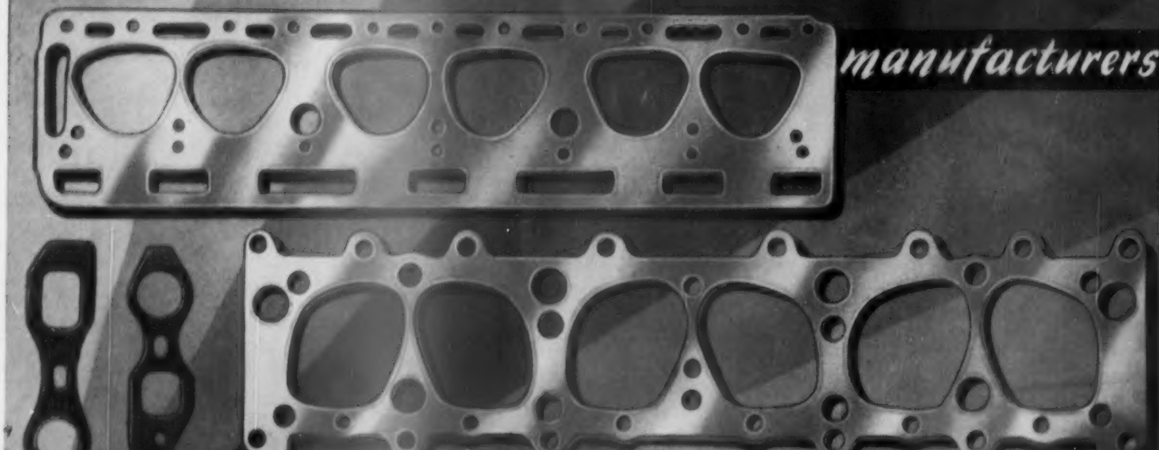
Cat. No. X6726
60 amp double
pole switch fuse

- Heavy waterproof cast iron case to withstand all climates and corrosive atmospheres.
- Switch fuses up to 100 amps, single pole and neutral, double pole, triple pole, triple pole and neutral.
- Switch blade assemblies quickly removable. Ample wiring space. Easy to install.
- Modern appearance. Sound design. Smooth action.

G.E.C. H W SWITCHGEAR

THE GENERAL ELECTRIC COMPANY LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

Copper and Asbestos Gaskets for Vehicle manufacturers



Manufacturers Enquiries Only.

MANUFACTURERS OF JOINTS AND GASKETS FOR ALL TYPES OF I.C. ENGINES AND POWER UNITS.

Specialists in the quantity production of small metal pressings.

THE COPPER & ASBESTOS WASHER CO. LTD
111-116, LIVERY STREET, BIRMINGHAM, 3
Telephone: CENTRAL 1467 Telegrams: "COPWASH"

It's the little things that matter!

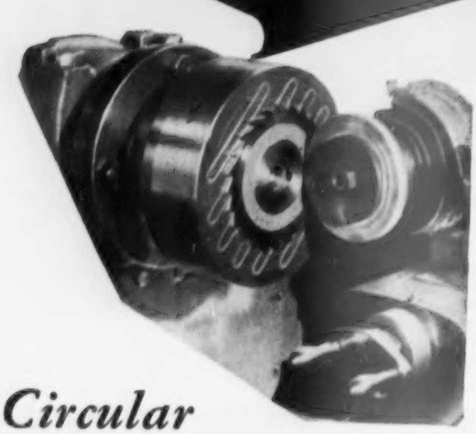
High precision components with an established reputation for quality and long life, minor items perhaps, but of major importance to the efficiency of the modern motor vehicle.

Concentric Components are produced in a modern factory specially designed and equipped to produce a better job at a lower cost.

CONCENTRIC MANUFACTURING CO LTD

TYBURN ROAD, BIRMINGHAM, 24
Telephone: EASt 2081-2-3-4-5
Telegrams: "Accelerate," 'Phone, Birmingham

it's quicker by permagic



Circular Permanent Magnet Chucks . . .

—in a variety of sizes complete the essential range of Lathe Chucks. Whether used in conjunction with a toolpost grinder, or on repetition turning, the advantages of easy fitting and trouble-free running are outstanding. Their use on internal and cylindrical grinding machines facilitates quicker and more efficient jigging, allowing large savings in production costs.

Ask for Publication P.M. 133/53
Supplies through appointed "Eclipse" Distributors

See our Stand No. 426 at the
INTERNATIONAL MACHINE TOOL EXHIBITION
OLYMPIA, LONDON
JUNE 22nd—JULY 6th, 1956

Eclipse

Magnetic devices designed to accelerate production

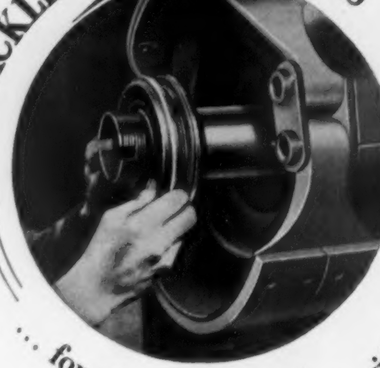
JAMES NEILL & CO. (SHEFFIELD) LTD., ENGLAND.

PM4

Teddington

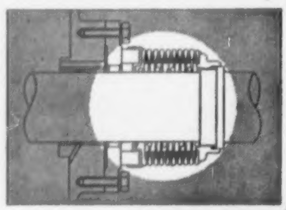
Photograph by courtesy of London Transport Executive.

PACKLESS SHAFT SEALS

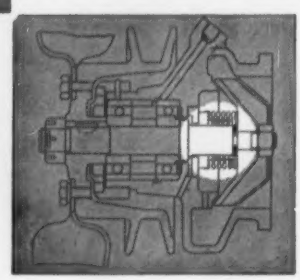


... for effective sealing against most liquids and gases

TEDDINGTON Shaft Seals are ideal for shafts running at speed. For example a $3\frac{1}{2}''$ dia. shaft running at 2,000 R.P.M. in temperatures up to 300°F is quite normal. As peripheral speed of the rubbing surfaces is the deciding factor, they can be fitted to larger shafts running at lower speeds or to smaller ones at high speeds. They will retain most liquids or vapours at pressures from 30-in. vacuum to 250 lbs. per sq. in., and are unaffected by continuous or intermittent running, or reversing.



The British Thermostat Company are the largest manufacturers of metallic bellows in Europe and, during the last 25 years, have acquired unique experience in the design and application of metallic bellows and packless shaft seals. Write for Leaflet BTC. 62

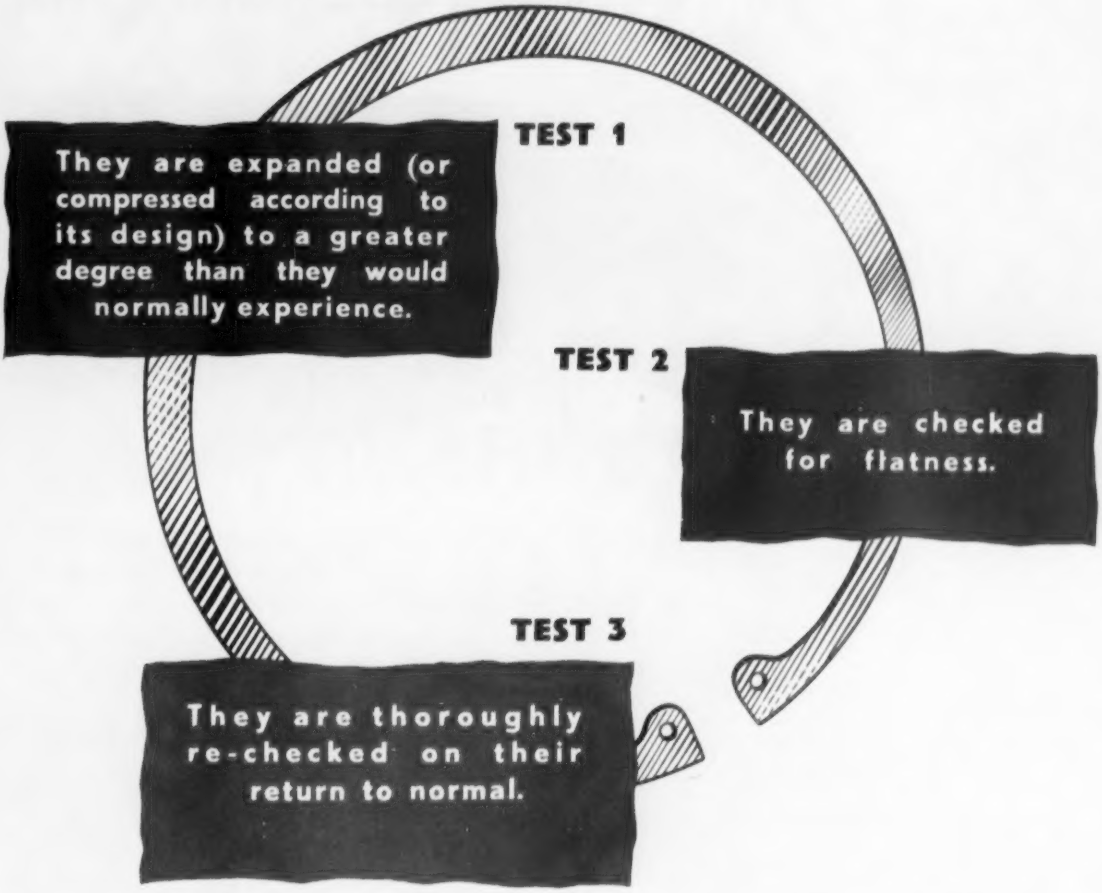


THE BRITISH THERMOSTAT CO. LTD.
SUNBURY-ON-THAMES, MIDDLESEX
Telephone : Sunbury-on-Thames 456

Telegrams & Cables: THERMOSTAT, SUNBURY-ON-THAMES, TELEX
Telex: 2-2742 TEDDCONTSNBRY

EVERY *SEEGER CIRCLIP IS TESTED*

. . . that's why they're **ALL** *360° safe!*



No random testing of Seeger Circlips ! Every single one is rigorously tested in three separate stages and no Seeger Circlip which fails any of the three tests ever reaches the customer.

By scientific design and accurate manufacture Seeger Circlips are all always perfectly circular when in position.

Write for our technical brochure on Seeger Circlips which explains how complicated methods of locating and retaining components in sleeves housings and on shafts can be dispensed with and the simple, sure, safe method of Seeger Circlips fixing be adopted.

BEST FIT SEEGER—THE ORIGINAL CIRCLIP

AUTOMOTIVE ENGINEERING LIMITED

(One of the Sheepbridge Engineering Group)

THE GREEN, TWICKENHAM, MIDDLESEX. 'PHONE : POPESGROVE 2206-9. 'GRAMS : MOTIF, TWICKENHAM.

OA/3318

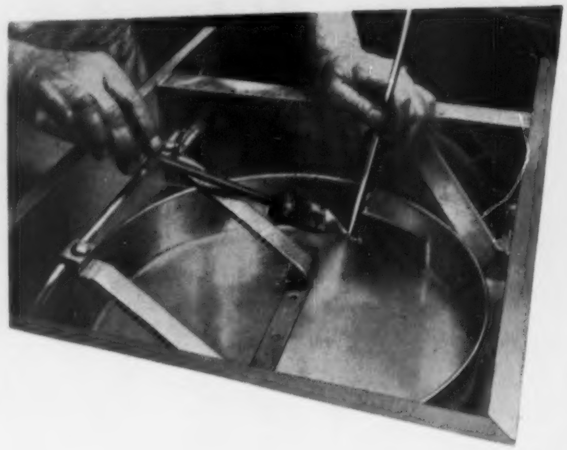
Fifteen years before Frozen Meat

Frozen meat was first shipped from the Argentine in 1877—fifteen years after the Bank of London & South America had opened its doors there. Since then, Latin American trade of all kinds has increased enormously, and with it has grown the influence and interests of the Bank. Today, the Bank holds a unique position as the *only* British bank in Latin America. It has branches in most of the important trading centres of that vast continent. Up-to-date reports on local markets, trading regulations and general economic conditions, are received regularly from branches overseas and are summarised in the Bank's *Fortnightly Review*; which is distributed to customers and made available to those who have business in Latin America, Portugal or Spain.

BANK OF LONDON & SOUTH AMERICA LIMITED

HEAD OFFICE AND LONDON OFFICE:
6, 7 & 8 TOKENHOUSE YARD, LONDON, E.C.2.
MANCHESTER: 36 CHARLOTTE STREET. BRADFORD: 55 WELL STREET.
CONTINENTAL REPRESENTATIVE'S OFFICE: TALACKER 35, ZÜRICH.

TWO MINUTE SOLDERING *Quiz*-



How much do you know about Soldering? We invite you to get out a pencil and try your luck with our quiz!

The picture is an "action-shot" taken recently in a famous manufacturer's Sheet Metal Shop.

1 The Unit shown is part of:
(a) A slot machine?
(b) A Radar reflector?
(c) A Gas meter?

2 The base metal being soldered is:
(a) Copper?
(b) Tinplate?
(c) Brass?

3 The Solder used is:
(a) FRY'S Abbey?
(b) FRY'S Tinman?
(c) FRY'S G.M.I.?

ANSWERS
1 (c) A Gas meter.
2 (b) Tinplate.
3 (c) FRY'S G.M.I. Solder — supplied in special strips for the Gas Industry.

ANY QUESTIONS?
If you have a particular soldering problem why not quiz our Research Department. They will be pleased to offer free their impartial advice.

Presented for your interest by

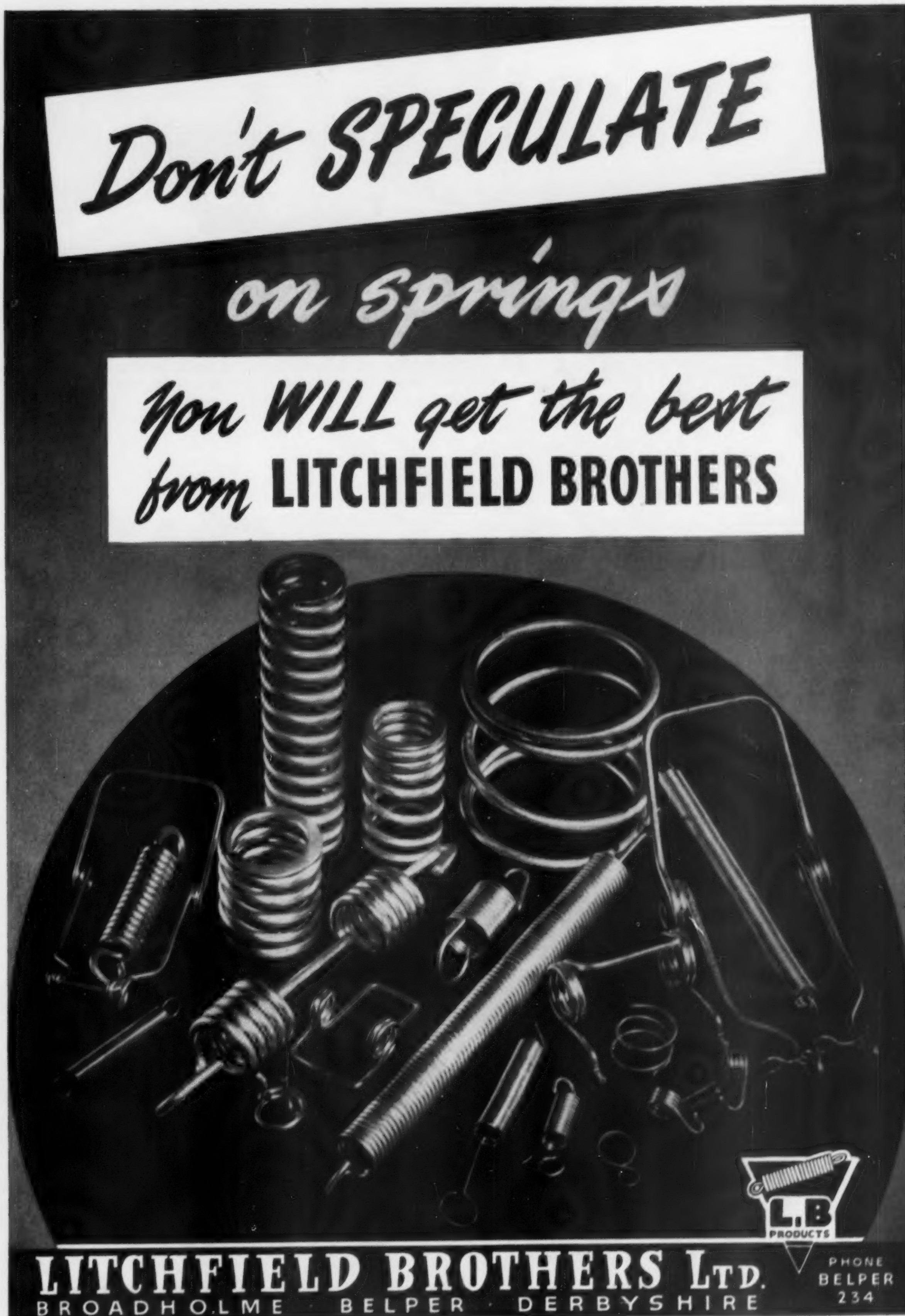
FRY'S

Export enquiries invited.

Metal Foundries Limited

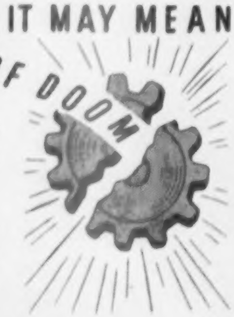
Tandem Works, Merton Abbey, London, S.W.19. MITcham 4023
And at MANCHESTER · GLASGOW · BRISTOL · DUBLIN

FRPIS


Don't SPECULATE
on springs
You WILL get the best
from LITCHFIELD BROTHERS
L.B
PRODUCTS
LITCHFIELD BROTHERS LTD.
BROADHOLME · BELPER · DERBYSHIRE
PHONE
BELPER
234

SALISBURY TRANSMISSION LIMITED, BIRCH ROAD, WITTON, BIRMINGHAM, 6.
TELEPHONE: EAST 3205 TELEGRAMS: SALISAXLE, BIRMINGHAM, 6.

FOR SOMEONE, IT MAY MEAN THE *CRACK OF DOOM*



You cannot afford to take risks in components when lives are at stake.

You can only be certain you have taken all precautions and tests when you use—

FEL ELECTRIC

Electro-Magnetic Crack Detectors

MODEL U4/5

Write for Catalogue

FEL ELECTRIC LTD

41, SIDNEY ST., SHEFFIELD, 1

for perfect photo-prints

Wolff's **FERROPRINT**

the 'light-stopping' lead

There's never a shadow of doubt about the firm impression made by a Ferroprint pencil. Black uniform lines always — distinctly better for clear photo-print reproduction of fine detail. You save time and work too, because no inking-in is required. Specially made for you — so ask for it by name: Ferroprint.

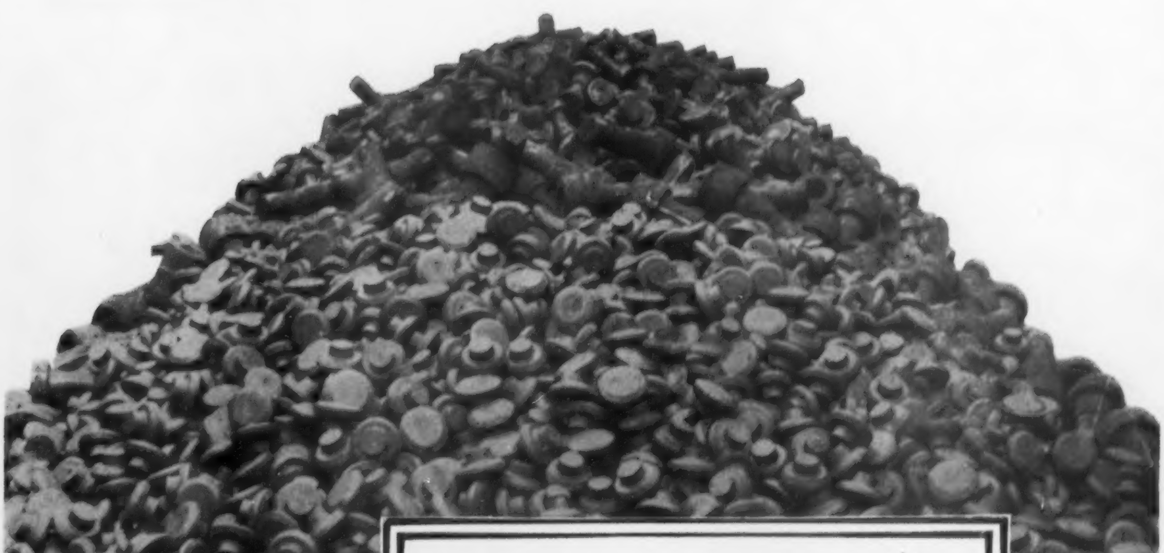
Ferroprint solves your pencil problems.

- *Long-lasting point.*
- *Consistency of degree.*
- *Smooth, extra-tough lead.*
- *Light-stopping properties.*

Made by THE ROYAL SOVEREIGN PENCIL CO., LTD., LONDON, N.W.10.

DONCASTERS

FOR DROP FORGINGS
IN LARGE OR
SMALL QUANTITIES



DONCASTERS
1778 D D

DANIEL DONCASTER & SONS LIMITED · SHEFFIELD

FORGINGS · DROP FORGINGS · HARDENED STEEL ROLLS · HEAT TREATMENT

F 39

Famous Quotations

"There is nothing more requisite in business than despatch."

Joseph ADDISON (*1672-1719*)

"It has long been an axiom of mine that the little things are infinitely the most important."

Sir Arthur Conan DOYLE (*1859-1930*)

"Genius is one per cent inspiration and ninety-nine per cent perspiration."

Thomas Alva EDISON (*1847-1931*)

"The best thing in all this world that can befall a man is to be born lucky."

Samuel CLEMENS (Mark Twain) (*1835-1910*)

"The glory of a workman, still more of a master-workman, that he does his work well, ought to be his most precious possession; like the 'honour of a soldier', dearer to him than life."

Thomas CARLYLE (*1795-1881*)

BUT

IF YOU REQUIRE THE BEST

ALUMINIUM & NON-FERROUS CASTINGS

LET

SANDWELL

QUOTE

SCC

Specialists in the production of the finest quality Sand Castings, Gravity Die Castings and Pressure Die Castings in all Light Alloys and Non-Ferrous Metals by the most modern methods.

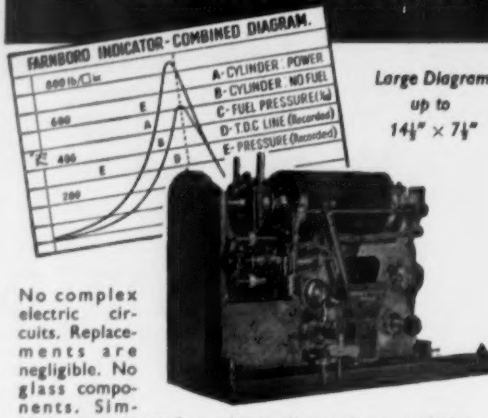
THE SANDWELL CASTING CO.

BANK STREET FOUNDRY, WEST BROMWICH

Tel: STOnecross 2231 (4 lines) · Grams: "REPCAST," WEST BROMWICH

DOBBIE McINNES

'FARNBORO'
ELECTRIC INDICATOR



Large Diagrams up to $14\frac{1}{2}" \times 7\frac{1}{2}"$

No complex electric circuits. Replacements are negligible. No glass components. Simplicity ensures ready understanding and manipulation without special knowledge. Very large diagrams. No Photography, thus saving time and trouble. Calibration Lines can be recorded while taking diagrams.

DOBBIE McINNES

DOBBIE McINNES LTD

Nautical & Engineering Instruments

BROOMLOAN RD. GLASGOW SW1

Also at SOUTH SHIELDS · LIVERPOOL · LONDON

MEMO

TOOLS AND MACHINE TOOLS for all Trades

from SCREWS to CEMENT MIXERS

It's so easy to stock through

Walkers

M. W. WALKER & STAFF LTD

ENGINEERS MERCHANTS

IBEX HOUSE, MINORIES, LONDON, E.C.3

'Phone: ROYal 8191 (10 lines) 'Grams: Makerlaw, Fen, London

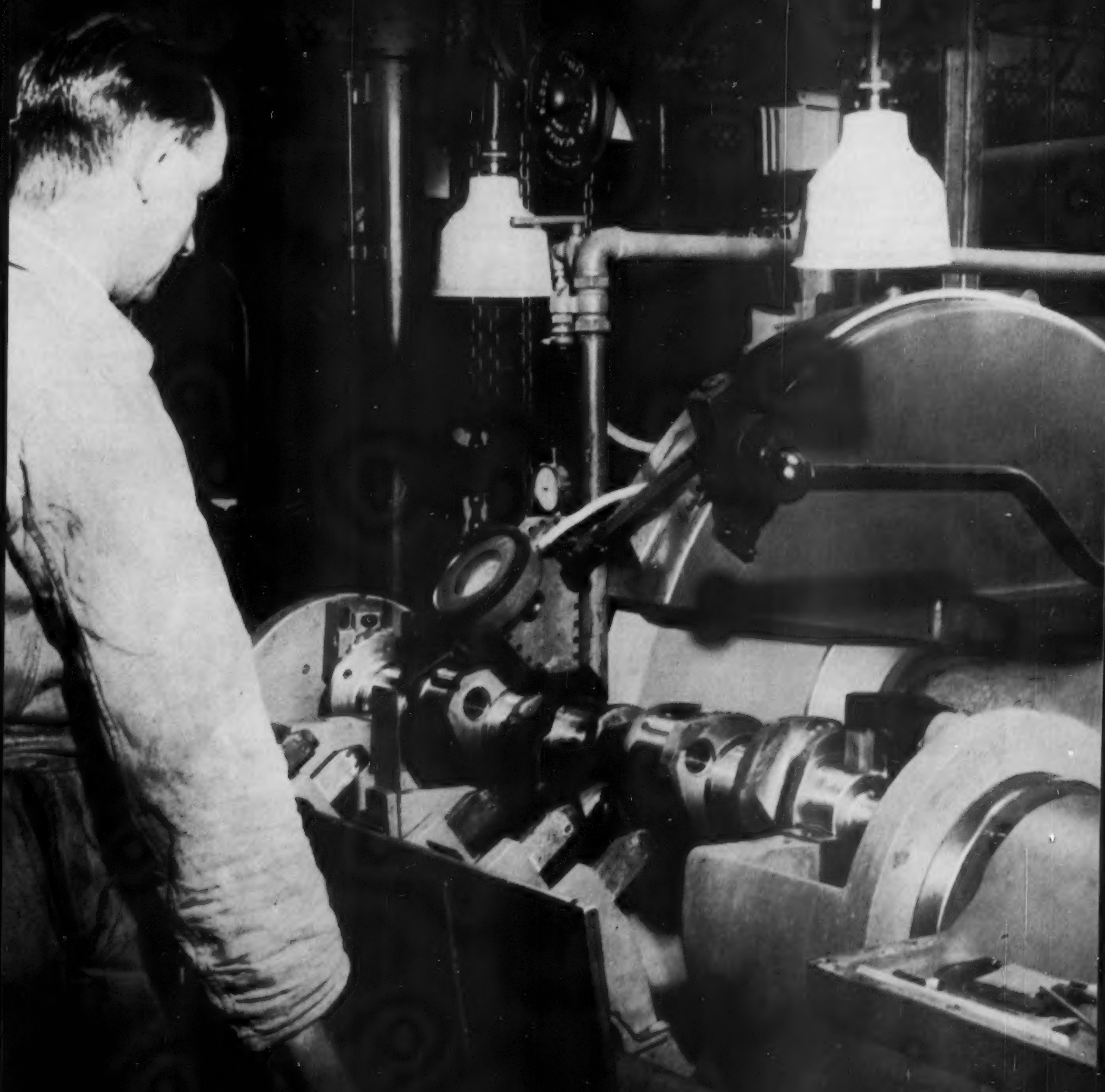
Middle East Branch—Bahrain Persian Gulf

NEWALL

Fast, accurate and economical grinding of crankshafts for the internationally renowned range of **A.E.C. vehicles** is achieved on Newall 'HAC' Automatic Crankpin Grinders. The 'HAC' Crankpin Grinder is one of a range of high production grinding machines manufactured by the Newall organisation.

Capacities: 16" x 48", 16" x 60", 16" x 72".

PHOTOGRAPH REPRODUCED BY COURTESY OF A.E.C. LTD.



Please address enquiries to:—

NEWALL GROUP SALES LIMITED

PETERBOROUGH : TELEPHONE - PETERBOROUGH 3227/8/9

NOW SATISFY YOUR DEMAND FOR PERFECTION

Use the *right* masking tape for every task. Permacel masking tape is used by most leading manufacturers. Here are examples of two tapes — and their uses.

The Use: Protecting machinery during manufacture (B.S.A).

The Tape: Permacel Self-Adhesive No. 30 Unbleached Cloth Masking Tape, made of unbleached cotton cloth, will stick instantly and firmly to any surface, yet comes away cleanly and easily. It is unaffected by many of the chemicals normally used in paints and dopes.

The Use: Protection during the spraying of Aircraft.

The Tape: Permacel Self-Adhesive Crepe Paper Masking Tape is a specially prepared tape for spray painting. It is highly flexible, readily conforms to uneven surfaces and goes around corners, evenly. It resists moisture and solvents in paints, varnishes, enamels and lacquers.

A GUIDE TO PERFECTION: *The Permacel brochure helps guide you through the intricacies of packaging tapes and subsidiary equipment. Over 400 examples classified. Send for your FREE copy to-day.*

PERMACEL
TRADE MARK

INDUSTRIAL MASKING TAPES

INDUSTRIAL DIVISION Dept. A.E.

Johnson & Johnson (GT. BRITAIN) LTD., SLOUGH, BUCKS.

CALIBRATED JETS

Amal Limited make jet-calibrating machines for checking carburetter petrol jets to conform to British Standard No. 720 of 1948. Amal Limited are equipped to manufacture and calibrate jets from .005" to .5" dia. — all of which discharge a specified flow to within close limits under specified conditions. 'Amal' calibrated jets find many applications for metering the flow of other non-viscous liquids, and also of gases such as town gas, butane, propane, methane, etc.

AMAL

Service to the Motor and other Industries

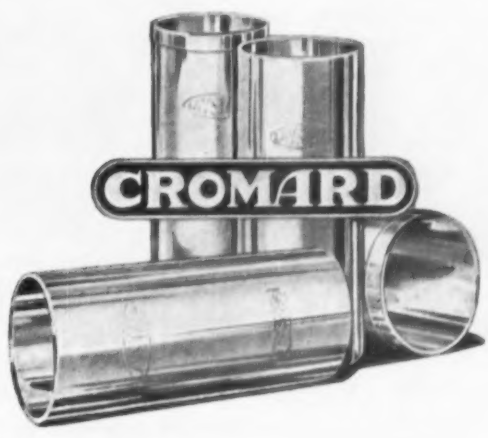
AMAL LTD., WITTON, BIRMINGHAM, 6

A/152

Laystall Production

Laystall crankshaft production is steadily increasing—from tiny refrigerator cranks to many types of road, marine and stationary diesel engines. Have you consulted LAYSTALL?

Hard chromed cylinder bores are endorsed by the world's leading automotive engineers, and utilized by some of the best makers. To chromium plate cylinder blocks is only really practicable on new engines, but to fit CROMARD liners is open to every wise owner and fleet operator.



It is significant that overseas demand for CROMARD liners is ever increasing especially where operating conditions are difficult.

MAKERS OF THE FAMOUS LAYSTALL "CROMARD" LINERS

LAYSTALL ENGINEERING COMPANY LTD.

Head Office :

53 Great Suffolk Street, London, S.E.1.

Telephone : WATerloo 6141

Laystall Laystall Laystall Laystall Laystall

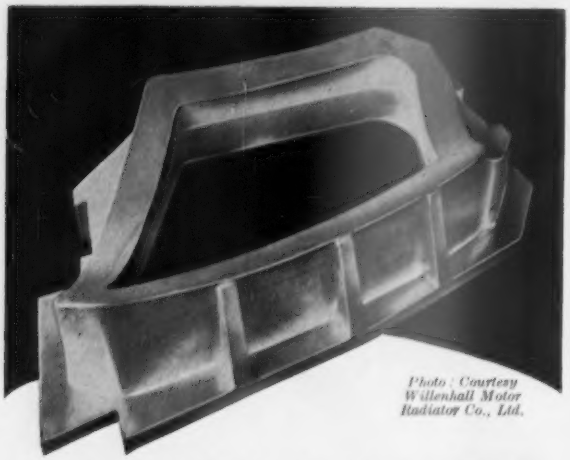


Photo: Courtesy Willenhall Motor Radiator Co., Ltd.

Press Tools & Stretcher Dies

AT A FRACTION OF THE COST using

KIRKSITE 'A'

LOW COST - SPEED - HIGH RECOVERY VALUE

Cost of dies made with KIRKSITE 'A' is only a fraction of those made of steel or cast iron, the more intricate the tool the greater is the saving. Use of KIRKSITE 'A' also means that dies can be produced in a few days eliminating long waiting periods for tools. A complete and speedy service for the production of both patterns and dies is operated. KIRKSITE 'A' data gladly sent on request. Also the Hoyt Buyers' Guide, listing all the Hoyt products and services.

PRODUCTION RUNS OBTAINED FROM KIRKSITE PRESS TOOLS

Kirksite 'A' and Plastics: *Kirksite is specially suitable for metal moulds for Polyester resins, having a very long life under operating conditions with Polyesters, whether plain or reinforced.*

200,000	Petrol tank pressings in 20 gauge steel from one KIRKSITE punch.
60,000	Aircraft jettison tanks in 16 gauge steel.
20,000	Delivery van sides in 20 gauge steel.
20,000	Runs in aluminium alloy sheet without any appreciable wear on tools.
50,000	Special plastic helmets on one set of KIRKSITE tools.
25,000	Special rubber parts from a KIRKSITE mould.

All the above tools were still serviceable.

HOYT LONDON METAL CO. OF GT. BRITAIN LTD.

DEODAR ROAD, PUTNEY, LONDON, S.W.15.
Telephone: VANdyke 6061.

PLAIN BEARINGS · ANTI-FRICTION METALS
BRONZES & LEAD BRONZES · FUSIBLE ALLOYS, ETC.

Improve your *SPOT WELDING*

with SYNCHROHEAT *Welding controls*

The new "**SLOPE**" technique, in which the weld current has a controlled rate of build-up from zero, gives remarkable improvement in reliability of spot welds. Power demand is reduced and electrode life is considerably extended when **synchroheat** slope controls are added to any size or type of spot, seam, butt or hot closing machines.

For further particulars write to: Bates & Bates LTD

73, ASHVILLE AVENUE, BIRMINGHAM, 34. *Tel: Castle Bromwich 2989*

B T-H

A. C. Direct-on-line CONTACTOR STARTER Type DOC71

for single-phase or poly-phase non-reversing squirrel-cage induction motors.

This new starter is elegant in appearance, sturdy in construction, and dependable in operation. It is available for motors up to 5 horsepower, and complies with BS.587 for "Frequent Duty", i.e. forty starts per hour.

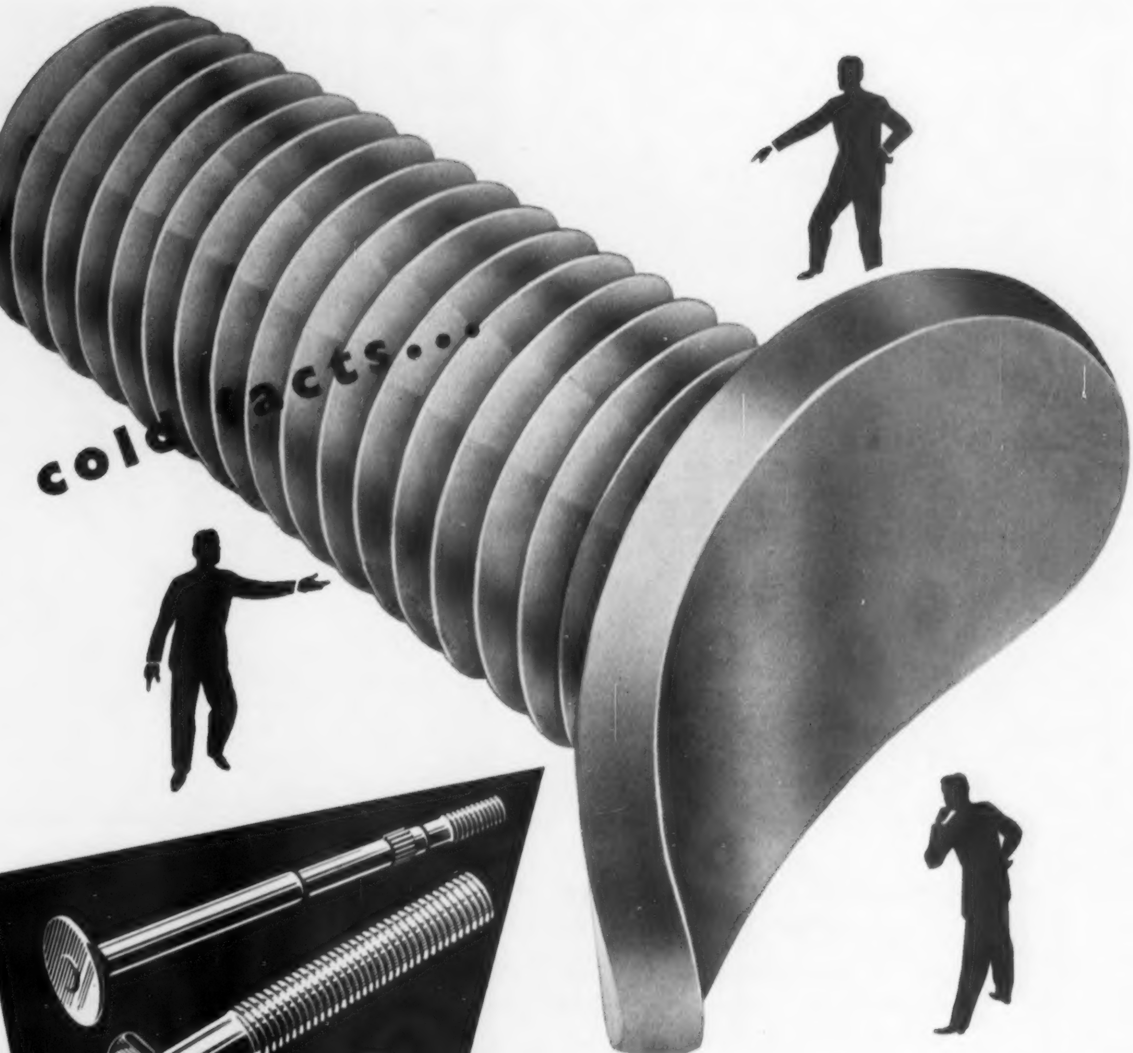
The starter, comprising a triple-pole contactor with normally-open auxiliary switch and triple-pole hand-reset thermal overload relay, is enclosed in a distinctive die-cast aluminium case with integral START-STOP push buttons.

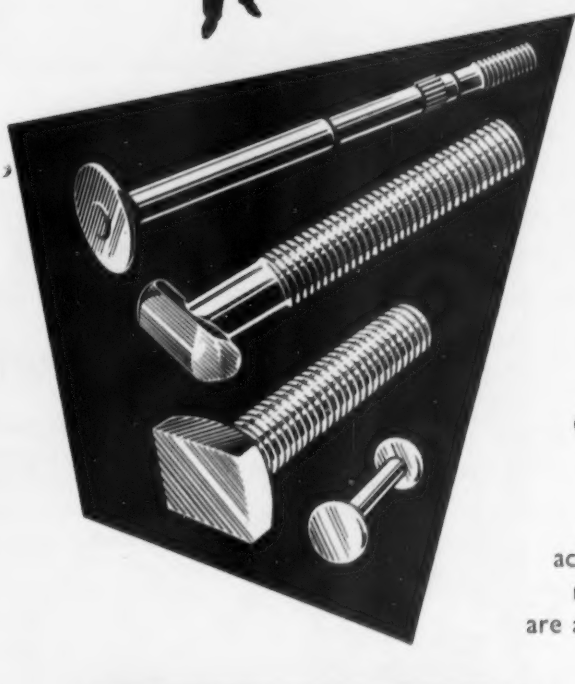
Up to 5 h.p. 200-550 volts 25-60 cycles

DELIVERY FROM STOCK

A4600

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, RUGBY, ENGLAND



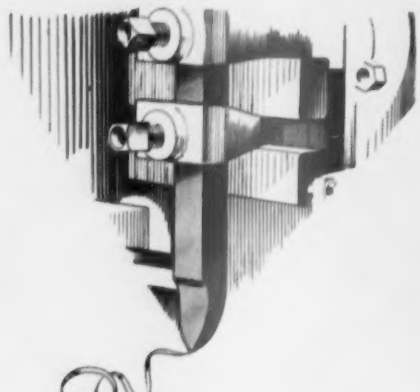


Linread technicians have always specialised in cold forging and its development. Cold forged products are stronger because the grain flow follows the shape of the finished part and there is no waste of material, while modern tool making methods ensure extreme accuracy. Special cold forgings may assist you to reduce costs or improve your product, and we are always ready to co-operate with manufacturers in the development of parts to meet their individual requirements, applying the same unsurpassed standards of quality and service as for our other products.

Linread

LINREAD LTD · COX STREET · BIRMINGHAM 3

THE STANDARD OF QUALITY



Durability

IS THE HALL MARK OF OUR HIGH SPEED TOOL STEEL

Available in six qualities covering a wide range of uses from cutting operations involving discontinuous chips with high tensile alloy steels to general workshop use. Write for brochure giving full details.

THE DARWINS GROUP

DARWINS LIMITED SHEFFIELD

D70

FOR REALLY RUGGED WORK YOU NEED

Details and information from:—

SMALL & PARKES LTD

HENDHAM VALE WORKS, MANCHESTER 9
COLlyhurst 2511

LONDON OFFICE 76 VICTORIA ST., SW1 VICtoria 1845/6

Every part an integral one

As specialists in the manufacture of all types of springs, pressings, clips, and "Metpaks" Shock Absorbers, Brayhead put quality above all, and at the right price. No matter how small the components may be, each one is designed and made to meet the exacting standards of the leading industrialists who use them.

BRAYHEAD (ASCOT) LTD.

FULL VIEW WORKS · KENNEL RIDE · ASCOT · BERKS.
Telephone: Winkfield Row 427/8/9 - *Telegrams:* Brayhead, Ascot

Specialists

IN GRINDING & POLISHING

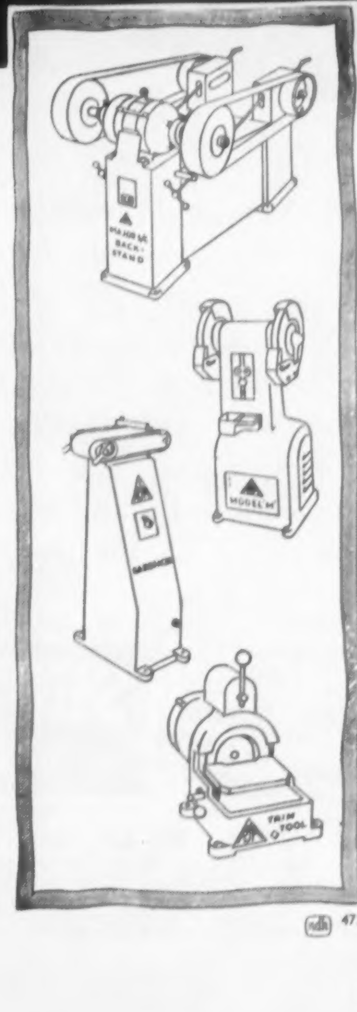
To meet the increasing need for higher standards of finishing throughout every industry R.J.H. have specialised for years to produce a range of Backstands, Bandfacers and Grinders to fit all requirements. The success of this aim is proved by the growing number of manufacturers who are reducing costs and increasing quality by using R.J.H. equipment.

We will be pleased to send on request literature covering complete range of equipment.

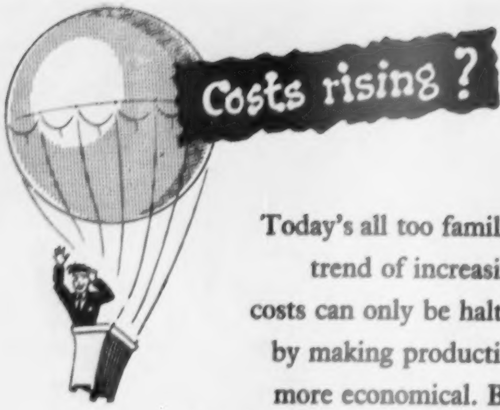
R. J. H. TOOL & EQUIPMENT CO. LTD.,
HECKMONDWIKE, YORKSHIRE
Telephone : Heckmondwike 490.

London & Southern Counties Representative:
E. J. SPREADBOROUGH, A.I.Mech.E., 30, Heath Street, N.W.3. Telephone: Ham. 8037.

INTERNATIONAL MACHINE TOOL EXHIBITION 1956, OLYMPIA,
June 22nd. — July 6th.
STAND No. 511, EMPIRE HALL GALLERY.



4731



Today's all too familiar
trend of increasing
costs can only be halted
by making production
more economical. But
how to do so raises problems
too. Fortunately, when
it comes to Malleable Iron Castings
your interests are our particular concern.

The Blackheart Malleable
Iron Castings we produce
enable you to bring
costs right down to earth.
Production technique is such that
castings are usually ready for
immediate jig machining. Our castings
conform to the Highest British Specification
accepted—B.S.S. 310. (1947) Grade 3.

BLACKHEART *Malleable* IRON CASTINGS

SHOTTON BROS·LTD

OLDBURY, NEAR BIRMINGHAM

Telephone : BROadwell 1631-2

Taking the strain!

Movement, vibration, power stresses, these forces provide a constant tug-of-war with every bolt and nut. That is why engineers use Richards "Hi-Strain" bolts which take such strains with maximum safety. Supplied Heat Treated to B.S.S. 1083 and B.S.S. 1768 Grade R Quality 45/55 tons tensile. Threads to Whitworth B.S.F., U.N.F. and U.N.C.

STAND No. D623 at
B.I.F. Castle Bromwich,
April 23rd — May 4th.

RICHARDS hi-strain BOLTS

CHARLES RICHARDS & SONS LTD., Darlaston, South Staffs.
Phone: James Bridge 3188 (8 lines) P.B.X. *Wires: "Richards, Darlaston."*

P.V.C. WING PIPINGS as supplied to leading motor manufacturers and body builders at home and abroad, have proved that plastic materials survive the severest tests. Whether as standard fittings used as wheel arch pipings or specially designed joint mouldings our sections are guaranteed to meet your particular requirements. Extrusions are our business — not just a department.

Please write for brochure on extrusions for the motor industry.

C. & C. MARSHALL LTD.
PLASTRIP HOUSE
OAKLEIGH ROAD NORTH, LONDON, N.20
Telephone: Hillside 5041 (3 lines) Cables: Tufflex, London
Telegrams: Tufflex, Norfinch, London

TUFFLEX

MAS Automatic Die Sinker

for HORIZONTAL . . .
VERTICAL . . .
MIRROR . . .
CIRCULAR . . .
SEGMENT COPYING

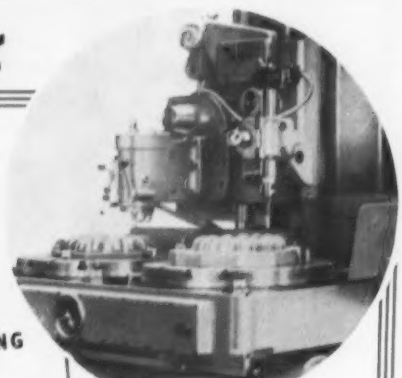


Illustration shows machine copying with vertical attachment fitted, and using the two rotary tables.

Arranged with two angle plates for simultaneous reproduction of two components

MODEL FK08c
TWO MILLING SPINDLES
SEE THIS MACHINE AT OUR SHOWROOMS

CAPACITY	
Table, 2 Rotary Tables	27[illegible]in. dia
Longitudinal Table Traverse (automatic) ...	39[illegible]in
Transverse movement of slide	15[illegible]in
Vertical travel of spindle head	31[illegible]in.
Spindle Speeds (8) ...	70 to 800 or 335 to 3,600 r.p.m.
Feeds (8)	
Longitudinal Table Feed (per min.) ...	[illegible]in. to 8[illegible]in.
Spindle Vertical Feed (per min.) ...	[illegible]in. to 5[illegible]in.
Net weight approx.	9[illegible] tons

Our Showrooms are only a few minutes from London Airport

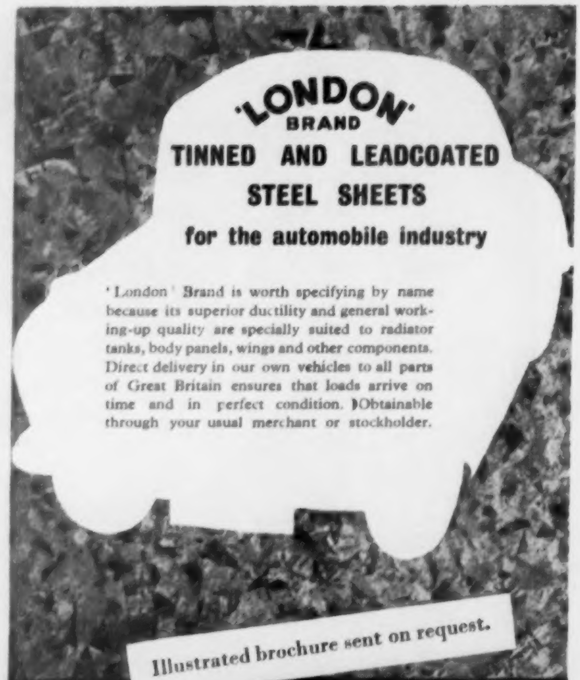
Sole Selling Agents
ELGAR *Machine Tool Company Limited*
HAMPTON ROAD WEST · HANWORTH · FELTHAM · MIDDLESEX
Phone: FELTHAM 4266 Cables & Grams: SHIPMENTS, FELTHAM

Nelson stands on his column

Intal stands on its own good name

INTAL

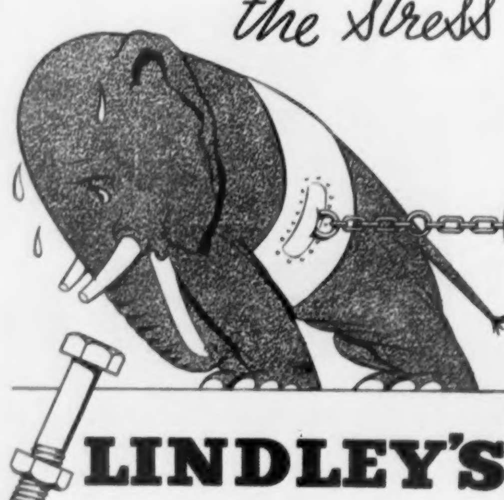
THE INTERNATIONAL TWIST DRILL CO. LTD.
INTAL WORKS · WATERY ST. · SHEFFIELD · 3
Telephone: 23072-3 Telegrams: Fluted, Sheffield
OBTAINABLE FROM YOUR STOCKIST
London Stocks: 16, ALDERSGATE ST., E.C.1.
Phone: MON. 3505
Glasgow Stocks: 50, WELLINGTON ST., C.2.
Phone: CITy 6994



SHIMWELL & Co. LTD
MANUFACTURERS SINCE 1875
WELLINGTON ROAD · LEYTON · LONDON · E.10
Tel LEYtonstone 2281-2

S 22

Whatever the stress



LINDLEY'S

QUALITY BOLTS, NUTS AND SET SCREWS
C. LINDLEY & CO LTD, ENGLEFIELD RD, LONDON N.1 Phone CLissold 0643 (4 lines) Grams BEAUVOIR, NORDO, LONDON

HEY MULTIPLE DRILL HEADS

★ COMPACT IN DESIGN
★ FIXED OR ADJUSTABLE CENTRE DISTANCES

Hey Multiple Spindle Drill Heads convert Standard Drilling and Boring Machines to High Production Machines permitting drilling of all holes in a component simultaneously, with production rates equal to those obtainable on expensive special purpose machines.

Compact design reduces to a minimum, distance from drill head to machine spindle, whilst careful selection of material ensures an extremely efficient light weight head.

Heads are available with any number of spindles, covering a wide range of sizes

MAXIMUM PRODUCTION ON DRILLING, REAMING, TAPPING AND SPOT FACING OPERATIONS

HEY ENGINEERING CO. LTD. COVENTRY 'PHONE: COVENTRY 88641

We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Gear Tooth Rounding Machines, Tapping Machines, End Facing and Centring Machines, Special Machine Tools for High Production.

Rainbow

Chas. Clifford Birmingham

'TELFOS' BRONZE — Chemical Composition, approx. 95% Copper, 5% Tin, ·02 - ·4% Phos; Tensile, 30-45 Tons per sq. in; Elongation, 15% - 20%; is a similar metal to Phosphor Bronze, yet possesses the remarkable advantage of machining three times as freely.

Write to us for a copy of our Descriptive Folder.

TELFOS BRONZE

REG. TRADE MARK

Free Machining Wrought Alloys

RODS AND BARS
Round, square, flat and hexagon.

saves labour . . .
speeds production . . .
cuts costs . . .

Charles Clifford Limited, Dog Pool Mills, Birmingham 30 Offices: London Glasgow & Dublin

M-W.198

YI LTD

QUALITY CONTROL

at all stages of manufacture ensures a trouble free product . . . . the reason why most manufacturers use High Tensile Cylinder Head, Gear Box and other Studs made

by

YARWOOD INGRAM & Co. LTD
PARKER ST. BIRMINGHAM. 16.
TELEPHONE: EDGbaston, 3607.

PRECISION CASTINGS

by:	*offer:*
PLASTER MOULD	Dimensional accuracy.
SHELL MOULD	Superfine finish.
AND OTHER	Fine detail & definition.
ADVANCED	Consistency.
PROCESSES	Homogeneous Structure.

PATTERNS & CASTINGS FOR SPECIALISED PROTOTYPES OR REGULAR PRODUCTION.

Consult:

UNIVERSAL CASTING DEVELOPMENTS LTD.,
269, ROTHERHYTHE NEW RD., LONDON S.E.16.
Phone Bermondsey 1337-8.

Support for the bosses

(As applied to Pistons where failure from fatigue must be eliminated)

Under working condition some deflection of the gudgeon pin occurs with resultant bending loads applied to the piston bosses. Whilst in certain designs the nature of these loads might be sufficient to cause fatigue failure, Specialloid designers now incorporate wherever possible, solid rectangular supports, the lower portions of which form the gudgeon pin bosses. The load is taken direct from the crown to the gudgeon pin, thus reducing ring belt deformation above the gudgeon pin housings. This is an important factor where ring sticking problems have been experienced.

The use of Specialloid pistons may also be argued as advantageous to Bosses anxious to reduce running costs!

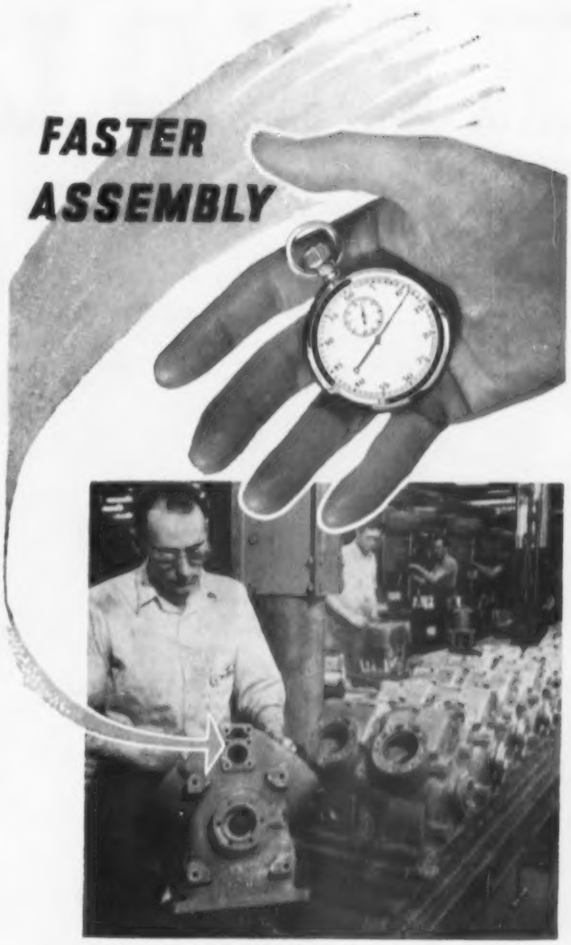
— it pays to specify

Specialloid

PISTONS

SPECIALLOID LTD., BLACK BULL STREET, LEEDS, 10. Tel: LEEDS 31471/7

FASTER ASSEMBLY



WITH...

HELI-COIL*

SCREW THREAD INSERTS

** Regd. Trade Mark*

No fractional gains either; substantially faster and surer assembly is a certainty and here's why—

Fit Heli-Coil! and reduce number of fastenings required. Use set bolts (which can now be shorter) instead of double threaded studs and eliminate "worrying" cover plates etc., into position. *Fit Heli-Coil!* and reduce torque loading for same duty. Reduce the wall boss size—no counterbore needed. Use lighter materials and improve thread strength. *Fit Heli-Coil!* and have all the advantages of a polished, rolled, internal thread.

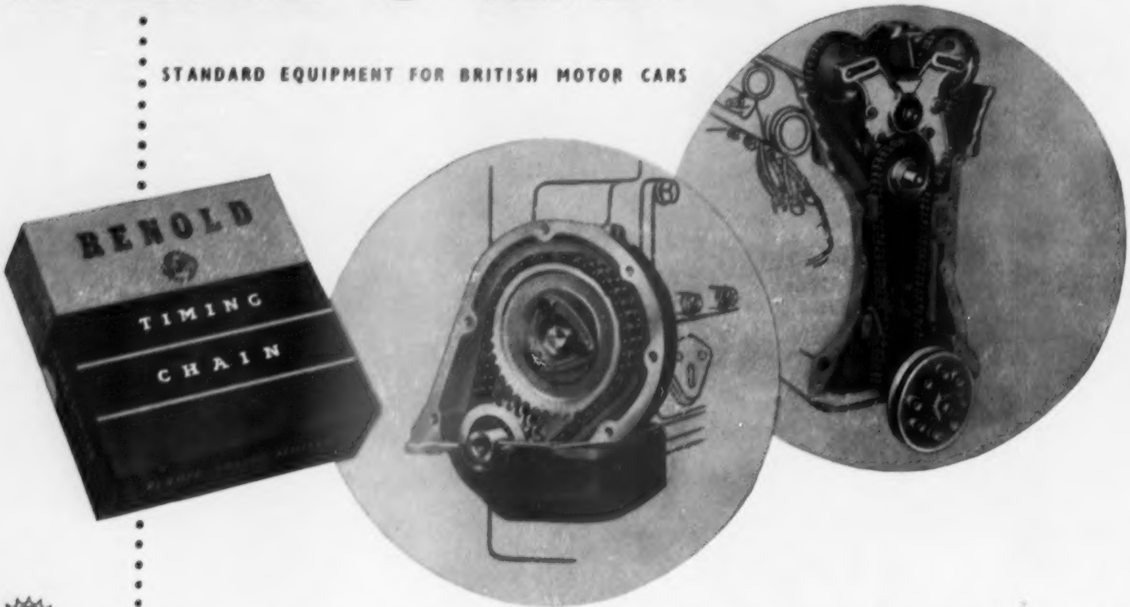
Please write for full information

ARMSTRONG PATENTS CO. LTD.

BEVERLEY · YORKSHIRE

RENOLD TIMING CHAINS

STANDARD EQUIPMENT FOR BRITISH MOTOR CARS



RENOLD CHAINS LIMITED · MANCHESTER

·IF YOU MUST HAVE

Reliability

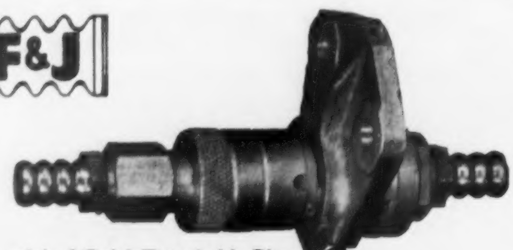
Specify HALE

Finest blackheart MALLEABLE IRON CASTINGS

SEND FOR DETAILS OF OUR FILM "MODERN MALLEABLE"

HALE & HALE (TIPTON) LIMITED DUDLEY PORT Staffs

F&J



The original Quick Detachable Pipe Coupling with auto. shut-off valve for vacuum or pressure up to 3000 lbs.

FEENY & JOHNSON LTD.

WEMBLEY :: MIDDLESEX Phone: WEMbley 4801 & 4802

MEKELITE

GEARED JOINT

INDUSTRIAL LIGHTING UNITS

For wall, bench or machine mounting. *Catalogue sent free on request*

MEK-ELEK Engineering Ltd.

17, Western Road MITCHAM, Surrey MITcham 3072

Next time you fit a

SHOCK ABSORBER-

insist on

NEWTON

TRADE PRODUCT MARK

REGISTERED

Hydraulic

SUSPENSION CONTROL UNIT

Standard Equipment on most British Commercial passenger-carrying vehicles

Manufactured under one or more of the following Patents

9017/54, 19978/53
688286, 629727
627170, 460851

★ **Send for illustrated Catalogue No. 226-1/1**

NEWTON & BENNETT LTD. VALETTA RD. LONDON W.3
Telephone Shepherds Bush 3443/6

A date for the diary of *everyone* in production engineering . . . the most comprehensive show yet seen in this country of the newest, finest, British, European and American machine tools and allied equipment! Study and compare at first hand the world's fastest, most accurate, most economical tools. See them working. Discuss their application to *your* industry, discuss *your* problems with the world's foremost production experts . . . it's Europe's most important engineering event this year. Don't miss it !

INTERNATIONAL MACHINE TOOL EXHIBITION 1956

Olympia · London · June 22—July 6

Exhibition open daily (Sundays excepted) 9.30 a.m. to 6 p.m. Admission 3/6d. Exhibits include machine tools, engineers' small tools, gauges and measuring equipment, testing equipment, presses and power hammers, heat-treatment plant, woodworking machinery.

Organized by The Machine Tool Trades Association, Victoria House, Southampton Row, London, W.C.1.

MARSTON products for the Motor Industry

Radiators and replacement blocks

Body parts in reinforced plastic laminates

Light Alloy Radiators of brazed construction

Flexible Fuel Tanks for special applications

Our design and Technical Service Departments will be glad to collaborate in solving car manufacturers' problems. Detailed technical data on all Marston products for the motor industry are freely available on request.

MARSTON EXCELSIOR LIMITED, WOLVERHAMPTON AND LEEDS

(A subsidiary company of Imperial Chemical Industries Ltd.)

MAR 142

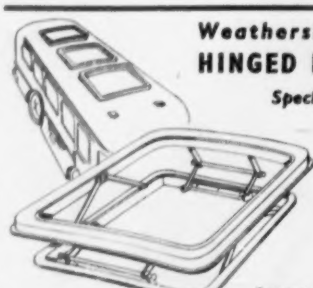
THE BUSH PEOPLE for NITRIDED JIG BUSHES and LINERS

NEW CATALOGUE AVAILABLE ON REQUEST

These jig bushes and liners are manufactured in accordance with B.S.S. 1098: 1953, the recommended sizes for the jig plate holes being in accordance with British Standard for B limits (B.S.S. 164:1941).

Established 30 years

LAWRENCE Bros. MILLWARD LTD
WICKERSLEY
ROTHERHAM
Tel. Wickersley 2041-2



Weathershields' 3-way Lift
HINGED ROOF VENTILATOR

Specified by Britain's leading Coachbuilders

Easily adjustable to 3 positions; each unit supplied complete ready for painting and screwing into position; made to suit any size opening to recommended maximum of 3' 0" square. Available in plain Perspex or in a range of attractive colours.

Full technical data on request.

'Phone: MID: 5876

'Grams "QUIPIT, B'ham"

Weathershields Ltd.
BISHOP STREET, BIRMINGHAM, 5.

In first class company

Pioneer Oil Seals have been specified by some of the largest and leading organisations in the country because they have withstood every sealing test with lubricants, chemicals and gases as well as being completely effective against dirt, water or any foreign matter.

Write for your free copies of the O-Ring Handbook and the Pioneer Catalogue. Engineers and Designers find both publications indispensable.

PIONEER OIL SEALS PLEASE
PIONEER OILSEALING & MOULDING CO. LTD.
A DIVISION OF J. H. FENNER & CO. LTD.
Factory & Head Office:
Cottontree Works, Colne, Lancs. Tel: Wycoller 411/2

TURQUOISE wins on every point

EAGLE "CHEMI-SEALED" TURQUOISE DRAWING HB

PRECISION GRADING

Turquoise gives exactly the line you want every time, because every one of the 17 grades—from 9H to 6B—is made from its own basic formula.

SMOOTHNESS

Turquoise smoothness speeds your work. Every particle of lead is lubricated with rare waxes, sealed in for permanent smoothness. No gritty flaws, no harshness.

OPACITY

100% Electronic graphite refined in the Eagle attrition mill to 1/25,000th" particles, produces a fine-textured lead that gives lines of maximum denseness for perfect reproduction.

STRONG POINTS

Turquoise points don't snap or crumble under pressure. The more compact lead—100% Electronic graphite again—takes and holds a needle point without crumbling.

CLEAN ERASURE

With Turquoise pencils there is no fear of "ghost" lines after erasure. Lines rub out cleanly every time.

EAGLE

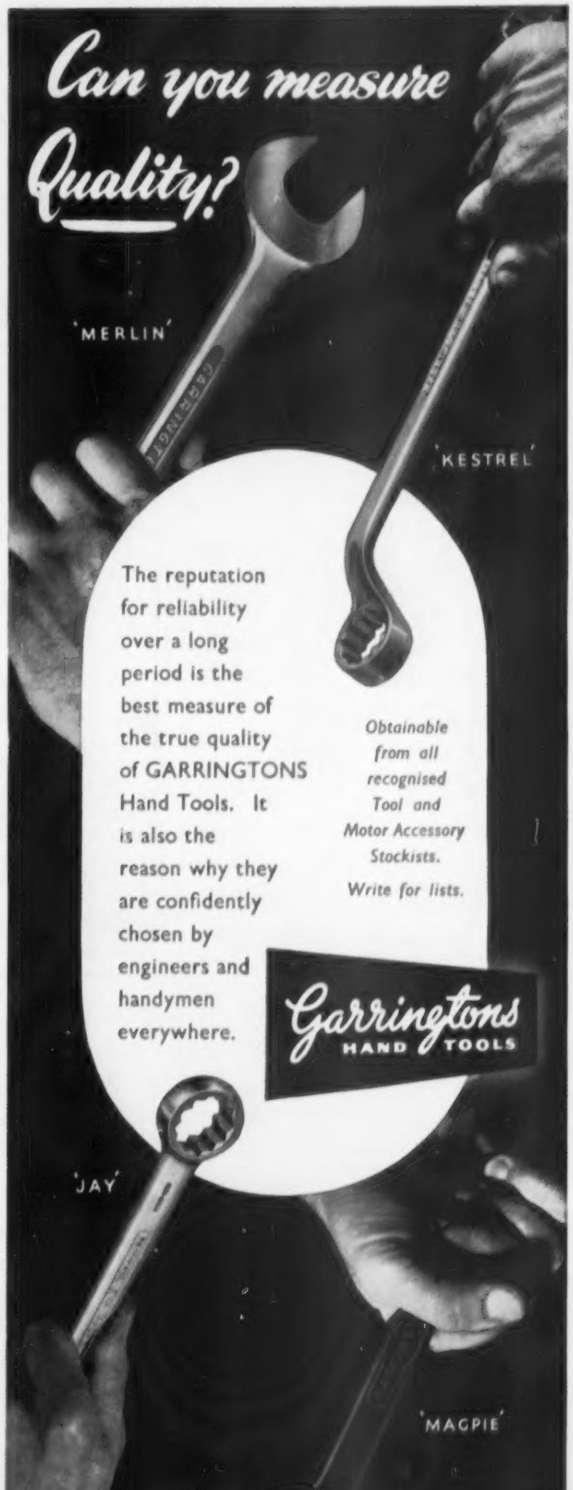
'CHEMI★SEALED' Super-bonded

TURQUOISE

DRAWING PENCILS

with 100% 'ELECTRONIC' Graphite

16 EAGLE PENCIL CO., ASHLEY ROAD, TOTTENHAM, N.17



CLASSIFIED ADVERTISEMENTS

RATE 4d. per word, minimum 4/-. Each paragraph charged separately. Box number 5 words—plus 1/-. Advertisements for the June, 1956, issue should be to hand not later than first post 28th May. No responsibility accepted for errors.

BALL BEARINGS

BALL and Roller Bearings. All types and sizes. Largest stocks, lowest prices. Same day despatch. Claude Rye Bearings, 895-921 Fulham Road, London, S.W.6. Renown 6174 (Est. 24). [5150

PATENTS

PATENT No. 708986, "Injectors for Liquid," for sale or licence. Apply: Chatwin & Company, Patent Agents, 253 Gray's Inn Road, W.C.1. [5176

THE Patentee of British Patent No. 694387, relating to "Improvements in Petrol Injection Carburation," desires to dispose of his rights either by way of sale or licence on a royalty basis. In the first instance please communicate with Eric Potter and Clarkson, Chartered Patent Agents, 317 High Holborn, London, W.C.1. [5172

SERVICES OFFERED

DESIGN Office Capacity available for Mechanical and Production Engineering. Special Machines and Projects. Norris Brothers Ltd., 53 Victoria Street, London, S.W.1. Tel.: Abbey 5444 [5099

A HIGHLY qualified staff and testing equipment are available to undertake research, design and development work in connection with internal combustion engines and other mechanical engineering products. Write Plint & Partners Ltd., Blakes Road, Wargrave, Berks. Tel.: Wargrave 407. [5179

SITUATIONS VACANT

PASSENGER Car Automatic Torque Converter Transmission Designer required to take charge of the development of a new British automatic transmission.

APPLICANT must be thoroughly versed in the subject, and cognizant of American technique. Promising opening for keen, qualified Designer. Apply Box 0640, c/o Automobile Engineer. [5159

A FUTURE with Ford.

WANTED—Men of Quality.

DETERMINED to maintain the highest reputation for quality, we invite applications from qualified automobile and mechanical engineers to join our Quality Control staff. Design and Experimental Engineers, Production and Works Engineers will be welcomed. The scope of their experience will be both challenged and extended as the company expands its manufacturing activity.

MEN with at least Higher National Certificate, aged from 35 to 45 and keen to make their mark have the basic requirements. They must be prepared to learn new techniques fast. In return they will find us top quality employers. From pay to pension, Ford is in the first flight. Why not forge ahead with Ford? The address is Salaried Personnel Department, Ford Motor Company Limited, Dagenham, Essex. Please quote reference QCA/2 [5166

HARRY FERGUSON RESEARCH LTD. require automobile design Draughtsmen, preferably with H.N.C. or equivalent. Interesting work on new projects, with excellent prospects. Non-contributory superannuation scheme. This Company is at present temporarily located near Banbury pending the erection of new premises near Coventry. Free transport available to and from temporary premises and Coventry.

APPLY in writing to:—

CHIEF Draughtsman, Harry Ferguson Research Ltd., Chipping Warden Aerodrome, Nr. Banbury, Oxon. [5170

METALLURGICAL Chemist wanted for large engineering works north of London. Experience of ferrous and non-ferrous analysis and spekker absorptiometer. New equipment being installed. Write Box V.736, c/o Streets, 110 Old Broad Street, E.C.2. [5183

DRAUGHTSMEN required for hydraulic tipping gears; also for commercial bodywork. Interesting work in modern factory. Good conditions. Apply to The Personnel Manager, Telehoist Ltd., Swindon Lane, Cheltenham. [5184

METALLURGIST wanted as assistant to chief for large engineering works north of London. Age 25-35, qualifications A.I.M. or L.I.M. Experience desirable on ferrous heat-treatment and all metallography, with knowledge of chemical analysis and induction hardening. New equipment being installed. Write Box V.735, c/o Streets, 110 Old Broad Street, E.C.2. [5182

AUSTRALIAN Patentees of an improved Curved Windscreen Wiper Blade require Agent, Distributor or Manufacturer interested in placing this line on the English market. Good, streamlined appearance. Low production cost. Proved 100% efficient. U.K. Patents held. Apply with full particulars to: L. G. Robinson Pty. Limited, G.P.O. Box No. 2779, Sydney, Australia. [5174

UNIVERSITY OF BIRMINGHAM

Department of Mechanical Engineering

GRADUATE SCHOOL OF THERMODYNAMICS AND RELATED STUDIES

A course available in the above School provides facilities for the study, at advanced level, of modern developments in Thermodynamics and allied subjects and of their applications in the general field of the heat engine. The normal entrance qualifications are an Honours Degree in Mechanical Engineering together with a minimum of two years of practical experience in industry. On completion of the twelve-month course commencing on 1st October, 1956, and including nine months attendance at the University, successful candidates qualify for the award of the degree of Master of Science. In special circumstances applications may be considered from graduates in other Sciences who hold satisfactory alternative qualifications. In the latter case it will usually be necessary for two years to be spent in completing the course. The award to successful non-graduate engineers is the Diploma of Graduate Studies.

The inclusive fee for the course of study is £71 1s. 0d. In certain cases where a student is not sponsored by an employer, the University may consider applications for the remission of this fee and, where essential, for the grant of a maintenance allowance during the period of attendance.

Further particulars and application forms may be obtained from the Registrar, The University, Birmingham 15. Applicants are advised to apply before 1st August but applications received after this date may be considered if places are available.

G. L. BARNES, *Secretary*

The University, Birmingham, 15. April, 1956.

SITUATIONS VACANT

ENGINEER required Jeddah, Saudi Arabia, capable dealing with mail, general technical work and repairing British, Continental and American cars and trucks, diesel engines, tractors, refrigerators, radios and air conditioners. Age between 35-40 Salary according to qualifications. Apply in writing, giving full particulars experience, qualifications, etc., to The Pyramid Trading & Shipping Co., 10 Wyndham Place, London, W.1. [5171

DESIGNER-DRAUGHTSMEN and Detail Draughtsmen are required by well-known commercial vehicle manufacturers in Lancashire, for chassis layout and detail work.

APPLICANTS should preferably have had experience in this class of work or its associated activities.

ALL usual facilities, including canteen, sports club, superannuation scheme, etc., available.

APPLICATIONS in the first instance in writing to:

ATKINSON VEHICLES LTD., Winery Lane, Walton-le-Dale, Preston [5173

THERE is a vacancy in the Research Department of a well-known automobile component manufacturer in the Birmingham area. The work involved is mainly concerned with the detail design of test rigs and equipment, and is of an interesting and varied nature. Applicants should have served a recognized apprenticeship, had drawing office experience, preferably in the automobile industry, and gained their Higher National Certificate in Mechanical Engineering. Full details in confidence to the Personnel Manager, Box 1085, c/o Automobile Engineer. [5175

REQUIRED: An Assistant Chief Engineer with energy and mental agility to deal with Instruments, Pressure Vessels, Filtration, Chemistry and Metallurgy, Hydraulics and Light Engineering in general within a day's work. We require, therefore, a man of all-round proved ability, preferably certificated. Age to be 28-35. Salary according to capabilities. This position is offered with the rapidly-expanding and pleasantly situated Company of Simmonds Aerocessories Ltd., Treforest Industrial Estate, Pontypridd, Glamorgan, and applicants should write, in confidence, to the Personnel Manager. [5177

EXCELLENT opportunity exists for a young Engineer to join a progressive North-Eastern Company and take charge of a rapidly expanding small Development Drawing Office. The work is interesting and varied, and embraces mining and mechanical handling equipment, together with special purpose "off-the-road" vehicles. Write in confidence, setting out full details, to the Chief Engineer, Eimco (Great Britain) Ltd., Team Valley, Gateshead, 11. [5180

CHEMISTS and Physicists, 25-40, preferably with experience in engineering, required for research and development laboratory of bearing manufacturers in Slough/Reading area. The work of the laboratory covers a wide range of both fundamental and applied subjects giving original thought. Applicants should possess a good degree in chemistry or physics and must be British by birth. Salaries will be in accordance with age and qualifications, from £950 p.a. at commencement. Modern laboratory, many benefits including pension scheme. Applications, in confidence, to Chief Chemist, Box 1371, c/o Automobile Engineer, quoting ML/3. [5181

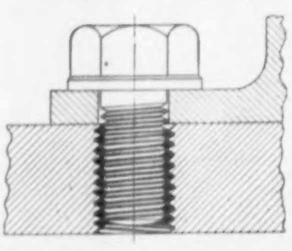
TUITION

A.M.I.M.I., City & Guilds, A.M.I.Mech.E., etc., on "No Pass-No Fee" terms. Over 95% successes. For details of Exams. and Courses in all branches of Auto., Aero., Mechanical Eng., etc., write for 144 page Handbook—Free. B.I.E.T. (Dept. 643), 29 Wright's Lane, London, W.8. [5178

BOOKS

WHY lack knowledge? If the car industry is your job get a copy of "Automobile Engineer's Reference Book" (82s. post free). An indispensable and comprehensive guide which can be yours at no additional cost for deferred terms. Write to James Thin (Bookseller), 55 South Bridge, Edinburgh. [5185

WIRE THREAD INSERTS



FOR NEW DESIGNS AND SALVAGE

CROSS MFG. CO. (1938) LTD.

COMBE DOWN · BATH

Tel.: COMBE DOWN 2355/6

BOLTS & NUTS

MARSDEN

MANCHESTER 1

Samuel Marsden & Son Ltd. Ard 1765.

Anderton

Write for **DATA SHEETS** *to Dept. A.1*

ANDERTON SPRINGS LTD · BINGLEY

Phone: Bingley 2388, 2351 & 2226

Grams: 'Circlips · Bingley'

CIRCLIPS

J. Brockhouse & Company Limited, West Bromwich

Invite applications for the following positions in their Transmission Division which is being established at their West Bromwich Works:—

GRADUATE ENGINEER with specialist knowledge of Hydraulics for research in the field of Hydraulic Transmission.

SECTION LEADER for Transmission Design. Comprehensive knowledge and experience of gears and gear boxes essential.

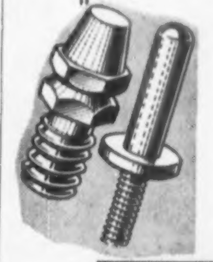
Salaries will be commensurate with qualifications and experience, and the appointments offer excellent prospects in a rapidly expanding field.

Good contributory pension scheme in operation.

The successful applicants will be required to work in Southport for a few months, during which period all reasonable expenses will be paid.

Apply in writing:—PERSONNEL MANAGER,
BROCKHOUSE ENGINEERING LIMITED, SOUTHPORT, LANCS.

"There's no parallel to this **BAR** work"



Made to customer's specification in any quantity.

For precision parts from the bar in any metal, particularly those which are not produced by the cold head or roll threaded process . . . consult the specialist machinists.

B.I.F.
B'HAM
STAND
D 414

PRECISION PARTS *from* *the* **BAR** *by*
M C L

M.C.L. & REPETITION LTD
POOL LANE - LANGLEY - BIRMINGHAM
Telephone: Broadwell 1115 (4 lines) and 1757

W. H. ALLEN SONS & CO. LTD.

BEDFORD, and ATLAS WORKS, PERSHORE,

require DESIGNERS, DESIGNER DRAUGHTSMEN and DRAUGHTSMEN

for their Gearing Department

The work will be concerned mainly with Epicyclic Gearing for high speeds and large powers for industrial and marine applications. There is a wide variety of work and scope for original thought. Previous gearing experience is not essential and most of the positions offered require general mechanical design ability rather than detailed knowledge of the technicalities of gearing.

The positions offered are permanent and pensionable, and the prospects are good in an expanding department, which is being transferred from Bedford to Pershore, Worcs., this summer

Successful applicants will be expected to work initially at Bedford, during which period an expense allowance will be paid. Ultimately they will be expected to move to a permanent address in the Pershore district, and they will be given financial help for moving

Applications should be made to the Personnel Manager, QUEENS ENGINEERING WORKS, BEDFORD, stating age, full details of experience and salary required.

AVELING-BARFORD, LIMITED
GRANTHAM

have vacancies in their expanding Drawing Office for

Designers and Draughtsmen

to work on earthmoving equipment, excavators and contractors' plant. Some knowledge of this class of work is desirable but not essential. Experience on heavy automotive work would be an advantage. Applications should be addressed to The Personnel Manager.

COTTON BAGS

FOR SPARE PARTS Etc.
Walter H. Feltham & Son Ltd
Imperial Works, Tower Bridge Road
Telephone: HOP 1784 LONDON, S.E.1

METAL TRAYS or WORKPANS
Standard sizes or made to your specification.
WM. HURLOCK JNR. LTD.
5-7, Kingston Hill, Kingston-on-Thames
KINgston 4526-7-8

GUY MOTORS LIMITED, WOLVERHAMPTON

have vacancies for a limited number of

EXPERIENCED COMMERCIAL VEHICLE DESIGNERS and SENIOR DRAUGHTSMEN for work on a long term development programme which is in progress to meet the ever increasing demand for the Company's heavy goods and passenger vehicles for home and export.

GOOD SALARIES
PENSION SCHEME
PAYMENT FOR OVERTIME
ASSISTANCE IN HOUSE PURCHASE
REMOVAL EXPENSES PAID

Applications should be addressed to the Chief Draughtsman

Fork-lift Trucks for hire

Youngman

PLANT HIRE SERVICE

W. C. YOUNGMAN LIMITED, WANDSWORTH WORKS, WANDSWORTH ROAD, LONDON, S.W.8. Telephone: MACaulay 2233 (6 Lines)

$$\frac{d^2\theta}{dx^2}+\frac{1}{x}\frac{d\theta}{dx}-\frac{\theta}{x^2}=-\frac{V}{D}$$

$$D\left(\frac{d\theta}{dx}+\frac{1}{m}\cdot\frac{\theta}{x}\right)=M_R$$

$$D\left(\frac{\theta}{x}+\frac{1}{m}\frac{d\theta}{dx}\right)=M_H$$

A 2/6 postal order will bring you our 40-page booklet on spring design, full of technical data and just the thing for your design department.

QUITE A SIMPLE MATTER, GENTLEMEN

And after a session with heads wrapped in wet towels, our design department will emerge triumphantly with the spring calculated to do the job better than any other. It's as well to call us in at the design stage, you know. More than thirty years facing up to this sort of thing has taught us most of the answers.

LEAVE IT TO **Lewis** *OF REDDITCH*

SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

THE LEWIS SPRING CO., LTD.

RESILIENT WORKS, REDDITCH. 'Phone : REDDITCH 720/1/2.

London Office : 122, High Holborn, W.C.1. 'Phone : Holborn 7479 & 7470.

INDEX TO ADVERTISEMENTS

	PAGE
Abingdon King Dick Ltd.	92
AC-Delco Division of General Motors Ltd.	38
Acheson Colloids Ltd.	66
Adamant Engineering Co. Ltd.	43
Aircraft - Marine Products (G.B.) Ltd.	15
Allen, W. H., Sons & Co. Ltd.	139
Aluminium Bronze Co. Ltd.	100
Amal Ltd.	122
Anderton Springs Ltd.	138
Angus, George, & Co. Ltd.	26
Archdale, James, & Co. Ltd.	109
Armstrong Patents Ltd.	133
Armstrong Whitworth & Co. (Pneumatic Tools) Ltd.	60
Automotive Engineering Ltd.	115
Automotive Products Co. Ltd.	5, 6, 7, 8
Aveling Barford Ltd.	139
Baldwin Instrument Co. Ltd.	104
Bank of London & South America Ltd.	116
Bates & Bates Ltd.	124
Bennett (Hyde) Ltd.	100
Benton & Stone Ltd.	62
Berry, Henry, & Co. Ltd.	93
Berry, Richard & Son Ltd.	108
Birkett, T. M., Billington & Newton Ltd.	95
Birlec Ltd.	19
Birmingham Aluminium Casting (1903) Co. Ltd.	Cover iv
Borg-Warner Ltd. (Morse Chain Division)	51
Bound Brook Bearings Ltd.	4
B.P. Petrol	24
Brayhead Springs Ltd.	126
British Belting & Asbestos Ltd.	Cover ii
British Electrical Development Association	22
British Oxygen Co. Ltd., The	46
British Piston Co. Ltd., The	53
British Thermostat Co. Ltd., The	114
British Thomson-Houston Co. Ltd.	124
Brockhouse, J., & Co. Ltd.	139
Brown, David, Corporation (Sales) Ltd., The	49
B.S.A. Tools Ltd.	86
Cape Asbestos Co. Ltd., The	16, 17
C.A.V. Ltd.	68
Cincinnati Milling Machines Ltd.	37
Clancey, G., Ltd.	98
Clayton Dewandre Co. Ltd.	20
Clifford, Chas. Ltd.	131
Climax Molybdenum Co. of Europe Ltd.	28
Collier & Collier Ltd.	132
Concentric Manufacturing Co. Ltd.	113
Cooper & Co. (Birmingham) Ltd.	96
Copper & Asbestos Washer Co. Ltd.	112
Coventry Motor Fittings Co. Ltd.	47
Crofts (Engineering) Ltd.	29
Cross Mfg. Co. (1938) Ltd.	138
Dartmouth Auto Castings Ltd.	73
Darwins Ltd.	126
Desoutter Bros. Ltd.	9
Dobbie McInnes Ltd.	120
Doncaster, Daniel, & Sons Ltd.	119
Dowty Seals Ltd.	39
Drummond - Asquith (Sales) Ltd.	1
Eagle Pencil Co.	137
Eaton Axles Ltd.	13
Edwards, F. J., Ltd.	90
Electro-Chemical Engineering Co. Ltd.	12
Elgar Machine Tool Co. Ltd.	129
Feeny & Johnson Ltd.	134
Fel Electric Ltd.	118
Feltham, Walter H., & Sons Ltd.	139
Fenner, J. H., & Co. Ltd.	42
Ferodo Ltd.	75
Firth Brown Tools Ltd.	54
Fletcher Miller Ltd.	106
Fry's Metal Foundries Ltd.	116
Fuller Gear Boxes	40
Fuller, Horsey, Sons & Cassell	110
Garringtons Ltd.	137
General Electric Co. Ltd., The	52, 112
Girling Ltd.	55
Gloucester Foundry Ltd.	105
Gordon & Gotch Ltd.	102
Guest, Keen & Nettlefolds (Midlands) Ltd.	96
Guy Motors Ltd.	139
Hale & Hale (Tipton) Ltd.	134
Hardy Spicer & Co. Ltd.	63
Harper, John, & Co. Ltd.	61
Heenan & Froude Ltd.	85
Herbert, Alfred, Ltd.	56, 57
Hey Engineering Co. Ltd.	131
High Duty Alloys Ltd.	82
Hoffmann Manufacturing Co. Ltd., The	33
Holroyd, John, & Co. Ltd.	3
Hordern-Richmond Co. Ltd.	94
Hoyt Metal Co. of Great Britain Ltd., The	124
Humphreys, J. H., & Sons	98
Hurlock, Wm., Jnr., Ltd.	139
Hydulignum-Jabroc (Tools) Ltd.	94
I.C.I. (General Chemicals, Heat Treatment) Ltd.	58
I.C.I. (Marston Excelsior) Ltd.	136
I.C.I. (Metals) Ltd.	107
Ilford Ltd.	32
Imperial Smelting Corporation	Cover iii
INA Needle Bearings Ltd.	129
International Machine Tool Exhibition	135
International Twist Drill Co. Ltd., The	130
Jackson, H., Ltd.	25
Jackson & Bradwell Ltd.	138
Johnson & Johnson (Gt. Britain) Ltd.	122
Kayser Ellison & Co. Ltd.	14
Kirkstall Forge Eng. Ltd.	41
Lawrence Bros. Millward Ltd.	136
Laycock Engineering Co. Ltd.	72
Laystall Engineering Co. Ltd.	123
Lee, Arthur, & Sons Ltd.	35
Lewis Spring Co. Ltd., The	140
Ley's Malleable Castings Ltd.	Cover i
Lindley, C., & Co. Ltd.	130
Linread Ltd.	125
Litchfield Bros. Ltd.	117
Lloyds (Burton) Ltd.	84
Long Meadow Felt Co., The	64
Machine Products Ltd.	18
Marsden, Samuel, & Son Ltd.	138
Marshall, C. & C., Ltd.	128
M.C.L. & Repetition Ltd.	139
Mek-Elek Engineering Ltd	134
Metalastik Ltd.	76, 77
Midland Motor Cylinder Co. Ltd., The	45
Mollart Engineering Co. Ltd.	94
Morris, B. O. Ltd.	80
Moss Gear Co. Ltd.	70
Neill, James & Co. (Sheffield) Ltd.	101, 114
Newall, A. P., & Co. Ltd.	21
Newall Group Sales Ltd.	121
Newton & Bennett Ltd.	135
Park Gate Iron & Steel Co. Ltd., The	103
Philidas Division of Whitehouse Industries Ltd.	34
Pioneer Oilsealing & Moulding Co. Ltd.	136
Prestons Ltd.	71
Ransome & Marles Bearing Co. Ltd.	Cover i
Renold Chains Ltd.	134
Richards, Chas., & Sons Ltd	128
R.J.H. Tool & Equipment Co. Ltd.	127
Royal Sovereign Pencil Co. Ltd., The	118
Rubber Bonders Ltd.	48
S. & D. Rivet Co.	122
Salisbury Transmission Ltd.	118
Salter, Geo., & Co. Ltd.	44
Sandwell Casting Co., The	120
Selson Machine Tool Co. Ltd.	30, 31
Sheffield Twist Drill & Steel Co. Ltd., The	65
Shimwell & Co. Ltd.	130
Shotton Bros. Ltd.	128
Silentbloc Ltd.	59
Skefko Ball Bearing Co. Ltd.	88
Small & Parkes Ltd.	79, 126
Specialloid Ltd.	133
Steel Co. of Wales Ltd., The	69
Tecalemit Ltd.	89
Terry, Herbert, & Sons Ltd.	2
Thomas, Richard & Baldwins Ltd.	27, 81
Thompson, John, Motor Pressings Ltd.	106
Toledo Woodhead Springs Ltd.	36
Torrington Co. Ltd., The	23
Tucker, George, Eyelet Co. Ltd.	102
Udal, J. P., Ltd.	108
Universal Casting Development Ltd.	132
Universal Dampers Organisation	50
University of Birmingham	138
Vandervell Products Ltd.	111
Walker, M. W., & Staff Ltd.	120
Ward, H. W., & Co. Ltd.	104
Ward, Thos. W., Ltd.	110
Wearing, Geo., Ltd.	92
Weathershields Ltd.	136
Wellworthy Piston Rings Ltd.	90
Weston, Chas., & Co. Ltd.	83
West Yorkshire Foundries Ltd.	78
Whittaker Hall & Co. (1929) Ltd.	91
Wickman Ltd.	10, 11, 67
Wilmot Breeden Ltd.	99
Yarwood, Ingram & Co. Ltd.	132
Youngman, W. C., Ltd.	139

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by James Cond Ltd., Charlotte Street, Birmingham 3. "Automobile Engineer" can be obtained abroad from the following: AUSTRALIA & NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd.; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd.; Wm. Dawson & Sons (S.A.) Ltd. UNITED STATES: The International News Co. Entered as Second Class Matter at the New York, U.S.A., Post Offices.

A Brave Front . . .

The very prominence of the grille and its importance as a dominant feature of motor-car styling, demands an attractive well-balanced design in harmony with the general body lines. Any motif or decorative detail must be clearly-defined, and the finish smooth and impeccable. With the further requirements of strength and economy, the obvious means of production is by die casting in MAZAK.

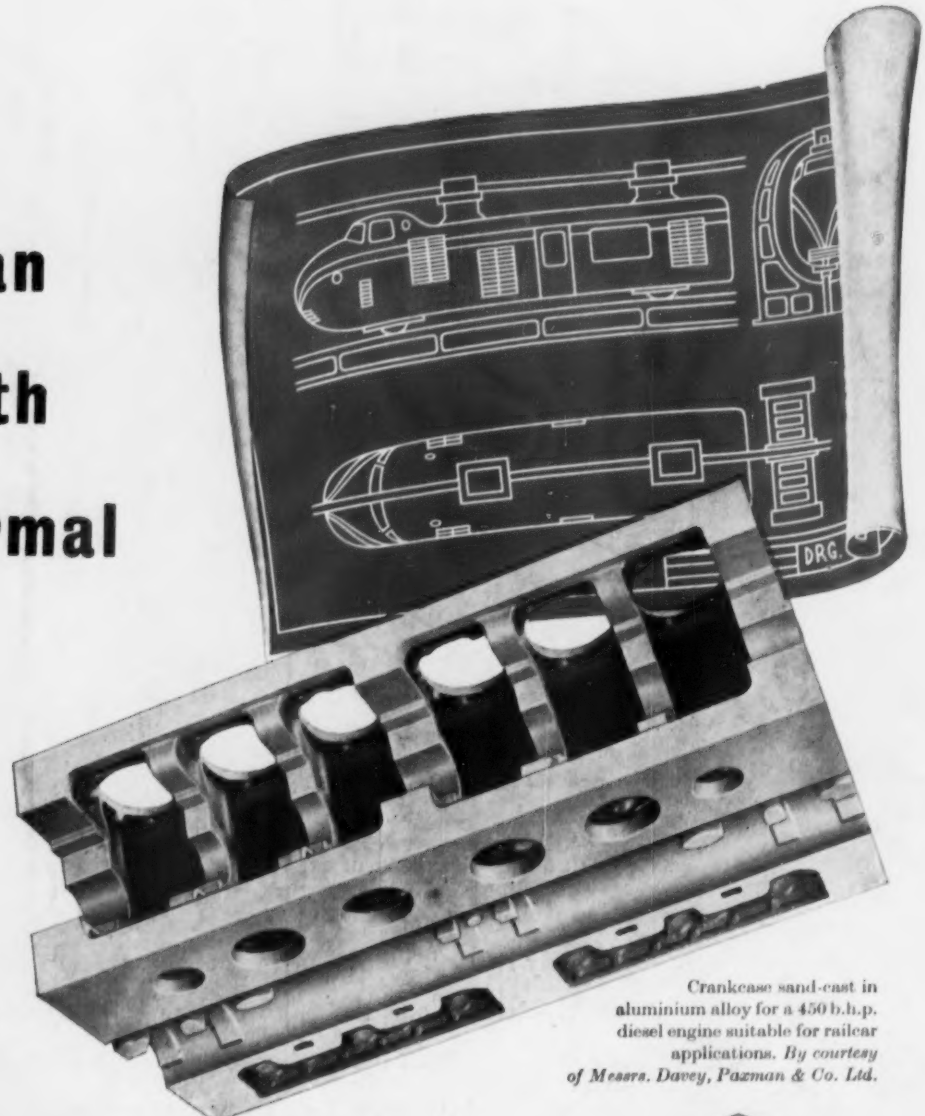
MAZAK

IMPERIAL SMELTING

U.K. MEMBER OF THE CONSOLIDATED ZINC CORPORATION LIMITED

IMPERIAL SMELTING CORPORATION (SALES) LIMITED, 37 DOVER STREET, LONDON, W.1.

plan
with
Birmal



Crankcase sand-cast in aluminium alloy for a 450 b.h.p. diesel engine suitable for railcar applications. *By courtesy of Messrs. Davey, Paxman & Co. Ltd.*

You get more than a casting from BIRMAL

A plan is the link between past experience and future efficiency. Birmal can be called upon at the planning stage, and will provide the lessons and benefits of fifty-three years of casting experience.

Birmal service includes advice on the selection of materials and casting processes, a wide choice of specifications and foundry workshop co-operation.

Birmal supply aluminium and magnesium castings in the sand, gravity die and pressure die casting.

Birmingham Aluminium Casting (1903) Co. Ltd.

BIRMID WORKS SMETHWICK BIRMINGHAM 40